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New Views of the Cause of the Corrosion of Iron.

At the recent meeting of the American Society for Testing Materials, Dr. Allerton S. Cushman, of the United States Department of Agriculture, made the first public announcement of the very interesting investigations he has been carrying on for several years on the causes which underlie the corrosion of iron. A number of new points were brought out, among which the most startling are that oxygen plays only a secondary role in the rusting of iron and that the best preventatives of rust are to be found among the most effective oxidizing agents known, such as chromic acid and its salts. This view is so contrary to all previous conceptions that it is naturally received with some incredulity when first heard, yet those who are familiar with the investigations and conceptions upon which the new theory of corrosion is based are of the opinion that the evidence which has been brought forward is not only convincing but conclusive. Dr. Charles B. Dudley, whose conservatism in expressing opinions on theoretical subjects is well known, stated at the close of the presentation of Dr. Cushman's paper that he considered this work to be the most important contribution to a metallurgical problem that has been made in the last quarter century. The same opinion was expressed privately by others who are familiar with the work.

The fact that chromic acid and its salts act as inhibitors of rusting has been known for some time, but no explanation of the curious phenomenon has ever been offered heretofore nor has its application to practice ever been suggested. Dr. Cushman has made a special study of this problem, and although it remains to be seen what practical benefits may develop out of these new ideas, it is most gratifying to be able to state that if any patents are granted covering rust inhibitors they will be taken out in accordance with the practice of the Department of Agriculture, so that they will be free for all American citizens. The investigation was begun by Dr. Cushman as a part of his study of the corrosion of fence wire, in the interest of the farmer. A farmers' bulletin on this subject was published by the Department of Agriculture about two years ago. It is safe to say that the public benefit which is likely to follow these investigations is on a par with the important economical benefits which will probably be derived from the same author's researches on the decomposition of feldspathic rocks and their use as fertilizers. Both of these investigations, made in the interests of the people, demonstrate the great national benefit which is derived from the scientific research of our federal departments, conducted by specialists of the highest rank. It is to be hoped that Congress will not fail to appreciate the advisability if not the necessity for providing the funds to carry on work of this kind, the expenditure for which is so small in relation to the public benefit.

If a text-book is consulted for an explanation of the rusting of iron, it will be found that carbonic acid has heretofore been generally held responsible for the formation of rust. Iron is supposed to be attacked by carbonic acid, with the formation of carbonate, which is then acted on by water and the oxygen of the air to form the red hydroxide known as rust, the carbonic acid being again set free to take up its destructive work. According to this theory, in an atmosphere which did not, like that of this earth, contain about four one-hundredths of one per cent. of carbonic acid, the rusting of iron would be an unknown phenomenon. That this, as well as the peroxide hypothesis which has lately been developed in England, must be relegated to the dump pile of abandoned theories, seems to be conclusively shown by these latest researches.

According to the electro-chemical or electrolytic theory which Dr. Cushman upholds, the first attack on iron is not made by oxygen, even in the presence of water, but by hydrogen in the form of the hydrogen ion. According to the modern theory of solutions, many substances when dissolved in water are dissociated into ions, which may be regarded as atoms carrying static electrical charges. Water itself, even when pure, contains a certain proportion of hydrogen ions, and the presence of many impurities, especially those which are by nature acid, increases the hydrogen ions and thus the tendency to attack iron and carry on corrosion. The action is entirely electrolytic, being continually accompanied by an exchange of the electro-static relations between the iron and the attacking hydrogen. Such oxidizing agents as the chromate and bichromate of potash inhibit rusting by polarizing the iron to the condition of an oxygen electrode, thus preventing the approach or attack of the hydrogen ion. One of the most extraordinary points brought out is that this polarization effect is to some extent lasting. That is to say, if iron is immersed or "pickled" in a concentrated solution of bichromate acid and is then washed and wiped, it is rendered passive, so that it resists electrochemical attack whether this take the form of rust formation or the well-known plating out of copper which takes place if the chromated specimen is immersed in a dilute solution of copper sulphate. In short, the action which goes on when iron rusts is in every respect analagous to that which takes place when iron is immersed in a solution of a copper salt. In the later case, copper ions carrying positive electrostatic charges are present, iron passes into solution and assumes the electro-static charge, while copper plates out and becomes visible. When iron rusts, iron passes into solution while hydrogen "plates out." Once in solution the oxygen of the air oxidizes the iron to the insoluble form of the red hydroxide known as rust. This electrolytic action can be shown taking place by the use of a special polar indicator which has been called "ferroxyl." It follows from this that anything that will inhibit electrolytic action will act the part of a rust preventative.

To what extent the various salts of chromic acid will come into use for the treatment of boiler feed waters and for "pickling" structural material will depend upon experiments carried out on a large scale. Dr. Cushman himself is emphatic in pointing out the necessity for care and conservativeness in approaching the practical application of these purely scientific investigations. One of the modern problems in boiler practice is the rapid corrosion of boiler tubes used in connection with turbine engines. The copper which is dissolved by the action of the setam jets impinging on the bronze blades of the turbine rapidly corrodes the iron in the boilers by the electrolytic action just described. Since it has been found that the presence of bichromates in feed water will prevent this action, it seems as though the solution of this important problem has been discovered. The engineering world will eagerly await the detailed publication of Dr. Cushman's researches, as well as the results of the practical tests which are sure to follow.

Structural Lessons of the San Francisco Earthquake and Fire.

Although much has been already written regarding the conclusions to be drawn from the structural results of the San Francisco earthquake and fire, the excellent reports submitted to the United States Geological Survey regarding the subject of Prof. Frank Soulé, Captain John Stephen Sewell, Corps of Engineers, U. S. A., and Mr. Richard L. Humphrey, structural expert of the Geological Survey, much of which was printed in The Engineering Record of June 15, are worthy of close consideration. These three engineers have made probably the most complete and thorough studies of the conditions resulting from the San Francisco catastrophe of all that have been reported. Furthermore they were completely unbiassed by any possible motives of self-interest, and their conclusions may therefore be regarded as based essentially upon the conditions as they found and interpreted them.

The first prominent conclusion to arrest the attention of the technical reader is the statement that the fireproofing in the city was, as a whole, defective, and, further, that it is practically impossible to construct any building which shall be entirely and absolutely fireproof in all respects. The latter dictum is not new nor unexpected, while the former statement finds so many exemplifications in every large city of this country that it was to be expected as a matter of course. Owners seem to fail completely to realize the imminent danger courted by cheap so-called fireproof methods. This feature of the old city is far too likely to be reproduced in the new, as it is constantly found in the majority of building operations in every large city. The authors of the reports mentioned recognize, however, that it is entirely feasible so to design buildings by a proper use of suitable materials as to make them so highly fire-resistant that they are to all practical purposes essentially fireproof.

A most important feature emphatically insisted upon by both Prof. Soulé and Captain Sewell is that the joints of columns with floors of all buildings shall be of the stiffest and strongest character. This is equally true of the steel-frame building and of the reinforced concrete structure. The former engineer speaks particularly of the steel-frame type of building whose adaptation to earthquake resistance as well as to fire resistance when properly protected with fireproofing material he comments upon in the most favorable terms. This also is what might be expected. The steel frame building, when properly designed, has in it all the elements of toughness and resistance to vibrations which could be desired, although such conflagrations as those of Baltimore and San Francisco have demonstrated in the most conclusive manner that the necessity of their being fireproofed is imperative. Captain Sewell states that "where reinforced concrete is used throughout, whether the building is very tall or not, great care should be taken with the design and execution of the connections between columns and members of the floor system. There should be heavy knee-braces for the connection of all girders and beams . . ." This, as The Engineering Record has frequently insisted upon editorially, is one of the most important features of concrete-steel design. It is interesting in this connection to observe that the building which will shortly become the future home of The Engineering Record is a reinforced concrete structure embodying among other advanced elements of design these essential features so strongly insisted upon by Captain Sewell. He lays down the fundamental proposition, although not in just these words, that the floors and columns of an earthquake-proof and fireproof reinforced concrete building should be actually continuous so as to secure the most rigid and unyielding structure attainable, and precisely these basic principles have governed the design of the building of the McGraw Realty Co., where the continuity of floors and columns has been secured throughout the entire structure by both the steel connections and the concrete. It is Captain Sewell's opinion that such a monolithic concrete-steel structure is secure against damage even by severe earthquakes, unless it should happen to lie across the actual slip. In fact, it is probable that unless such a slip were of considerable magnitude, the building would be but little damaged even under such circumstances.

It is not entirely clear why he should limit the extreme height of reinforced concrete buildings to 125 ft.; or again why he should state that the "bracing of a reinforced concrete building of any height" is a problem which "has not been solved as yet." It may be admitted at once that the great majority of buildings of this class do not show a satisfactory solution of that problem, but in such a reinforced concrete structure as the McGraw building it is quite reasonable to state that the problem has been completely solved throughout its height of nearly 150 ft. above the street. The type of columns employed in that building, involving every essential element of good design set forth by Captain Sewell, the steel portions of which are essentially continuous with the reinforcing steel of the floor girders and beams, attain most completely the element of rigid bracing which he so properly insists upon. As a matter of fact the general system used in the design of that building is capable of being adapted to any degree of rigid bracing and practically to any height to which it may be desirable to carry the structure.

One of the most essential lessons to be learned from the great conflagrations of the near past, which these experts insist upon with most commendable emphasis, is the imperative need of a greatly improved system of fireproofing, not only in the interior parts of the structure but especially for the exterior openings. It is well known, as they maintain, that many large buildings would have escaped an interior conflagration if the exterior openings had been properly guarded with suitable metal or metal-covered shutters or doors. Moreover, buildings of the steel frame or reinforced concrete type so fitted would frequently prove most effective fire stops, and an effective fire stop is practically the only real bar to the rapid extension of a great conflagration.

These three reports constitute the most valuable of the latest additions to the literature of earthquake-proof and fireproof building construction. They should be carefully studied by the building department of every large city and their recommendations should be heeded. The general principles which they set forth are sound and not the least of their services to modern building construction is the authoritative statement of the excellent part played by the few substantial reinforced concrete buildings exposed to the San Francisco fire.

It should be added, however, that fireproofing is largely a matter settled by the owner. Baltimore and San Francisco have shown the importance of good fireproofing, but owners too rarely are willing to pay for it.

Flood Prevention.

It is interesting to observe that last Spring's freshets and floods in a good many portions of the country have at last aroused communities exposed to injury from these occurrences to the advisability of taken measures to prevent them. It is not often that a single city is able to carry out a complete system of works for this purpose, and until co-operative measures can be arranged between several cities or under the direction of State commissions, it is useless to expect the best results. A good example of this is shown by the works constructed at Ithaca which were recently described in this journal; in order for them to be of maximum efficiency it is essential for various improvements to be undertaken by the State of New York in connection with its barge canal work. It is this interrelation of all parts of a waterway which produces such a complication in flood-prevention measures. Numerous communities have learned by bitter experience that works constructed for a short stretch of river may increase instead of diminish flood troubles, unless great care is taken to provide for carrying off the water below the improvement. Probably the unfortunate experience of many communities in constructing small and inadequate preventative works has been responsible for the general backward state of such undertakings in this country at the present time. Nevertheless the large flood loss which takes place almost every year has at last aroused public appreciation of the importance of the subject and has proved that it is sound business economy to spend a considerable sum of money in order to prevent such damages.

The methods to be followed in flood prevention are extremely varied, and anyone who will take the time to study the numerous works built in different parts of Europe will be impressed by the complexity of the problems and the necessity of regarding each one as an independent subject of investigation in order that not only the cause of the freshet but also its remedy may be ascertained. There is a prevalent opinion that forestry is a universal preventive of floods, but there are portions of Europe where works have been executed with successful results in which no reliance was placed on trees. Where a mountainous country has been stripped of its forests for some time and the rocky surface has been bared by rain, it is idle to expect more trees can be grown successfully. Other preventive measures must be taken in such districts, but national economy as well as the regulation of stream flow demand that forestry should be given a thorough trial where it stands any show of success. It is to be regretted that the bill for the establishment of forest reserves in the Appalachian and White Mountains, passed without dissent in the United States Senate at its last session, failed to pass the House, although it was unanimously recommended by the House Committee on Agriculture. This is one of the most important bills from the standpoint of flood prevention and forestry introduced for some years. The regions which it was proposed to set apart for forest reserves not only furnish the water supply for numerous communities and power plants but must also eventually supply valuable timber, and if they are not protected by federal legislation it is probable that their denudation and its attendant evils will continue. Fortunately the importance of this bill was thoroughly recognized by both branches of Congress and it is but reasonable to expect its passage at the next session, provided all who are interested in the subject, sufferers from floods, believers in the federal control of our important forests and users of water for power purposes and municipal supplies, take steps to urge their Congressmen to push forward this bill as speedily as possible at the next session.

While the prevention of floods by protective measures on the watersheds from which the freshets come is a practicable measure for many districts, it is out of the question for places like Kansas City or New Orleans. The government has investigated the flood conditions at the former city and the probability of a recurrence of great damage there has been pointed out by a board of army engineers. These specialists have shown that just so long as the city encroaches on the natural waterway of the Kaw River, there will be danger of great damage. At New Orleans the situation is different. The city is guarded by a system of levees controlled by municipal officers, independently of the works executed elsewhere under the direction of the State Board of Engineers. These city levees were recently examined by order of the Governor of Louisiana and the engineers reported that out of thirteen miles of embankment on the left side of the river none is up to the State standard of 5 ft. above the flood mark of 1903. Moreover there are many places in this embankment which are declared to be unsafe and others that are unsatisfactory. On the other bank of the river the fourteen miles of municipal levees also present many features which are not what they should be. The results of the investigations seem to have aroused public appreciation of the dangers of the situation in New Orleans, and it is to be hoped that definite action will be taken before long to remedy the defects.

The Importance of Water Powers.

The Taylors Falls plant, which is described in this and the last issue of The Engineering Record, is a type of the hydraulic work of great economic importance now steadily under way. It is not at all sensational in capacity, voltage or distance of transmission, but it is a fine example of a well-planned and executed plant admirably constructed for economical and reliable service. Its most novel and interesting feature is the way in which the dam and power house are worked out together in massive concrete construction, giving a compact and convenient plant with the important feature of very short penstocks giving a most excellent opportunity for close regulation. The lesson it teaches is chiefly the economic one of the facility with which central stations can utilize water power anywhere within a radius of many miles to keep down the cost of electrical energy. At the present time electrical power transmission involves little of difficulty and is settling down to standard forms of practice. The voltage of 50,000 used in this Taylors Falls system would have been looked upon as rather hazardous even a few years ago. To-day it must be regarded as within the bounds of safe and conservative practice. In fact, one might almost say that 60,000 volts is now standard for large projects involving long transmissions, and 50,000 is certainly well within safe bounds.

The question of reliability which used so often to be raised with respect to long transmission has now been pretty thoroughly settled in the affirmative. It is true that lines sometimes break down, but with well-constructed duplicate circuits the chance of actual failure of service is not a frequent one. Against it must be set off the fact that the chance of failure of the motive power is considerably less with water than with steam. Something may now and then go wrong even with a hydraulic plant, but there are fewer chances for little things to cause a shut down than in a steam plant. It is a wise and far-sighted thing for a central station to develop hydraulic power for its own use and it nearly always pays from the start. Coal prices are upon the up grade and no return trains are running, so that what pays reasonably well now will be a splendid investment a few years hence. Plants like this at Taylors Falls are permanent. They are certain to give many years of valuable service, and there is little likelihood that the apparatus will go out of date for the purpose of its use. The distributing appliances may change and the receiving end of the plant go out of date, but there is small probability that the generating station will become materially less economical as time goes on. Dynamos and water wheels are unlikely to be materially improved in efficiency, and modern electrical machinery has a very long, useful life. As a matter of fact the first polyphase generators put into operation in this country some fourteen years ago are still in successful operation, and generators as built to-day are even more durable. It pays to do a thing a well, if at all, and plants built as thoroughly and planned as carefully as this one at Taylors Falls are likely to justify the wisdom of their constructor for many years to come. As time goes on more and more of the larger central stations are likely to do likewise. Few can find power so near at hand as in Minneapolis, but transmissions of a hundred miles or more are now as safe and practicable as those of twenty or thirty miles a few years ago, and are not to be feared.

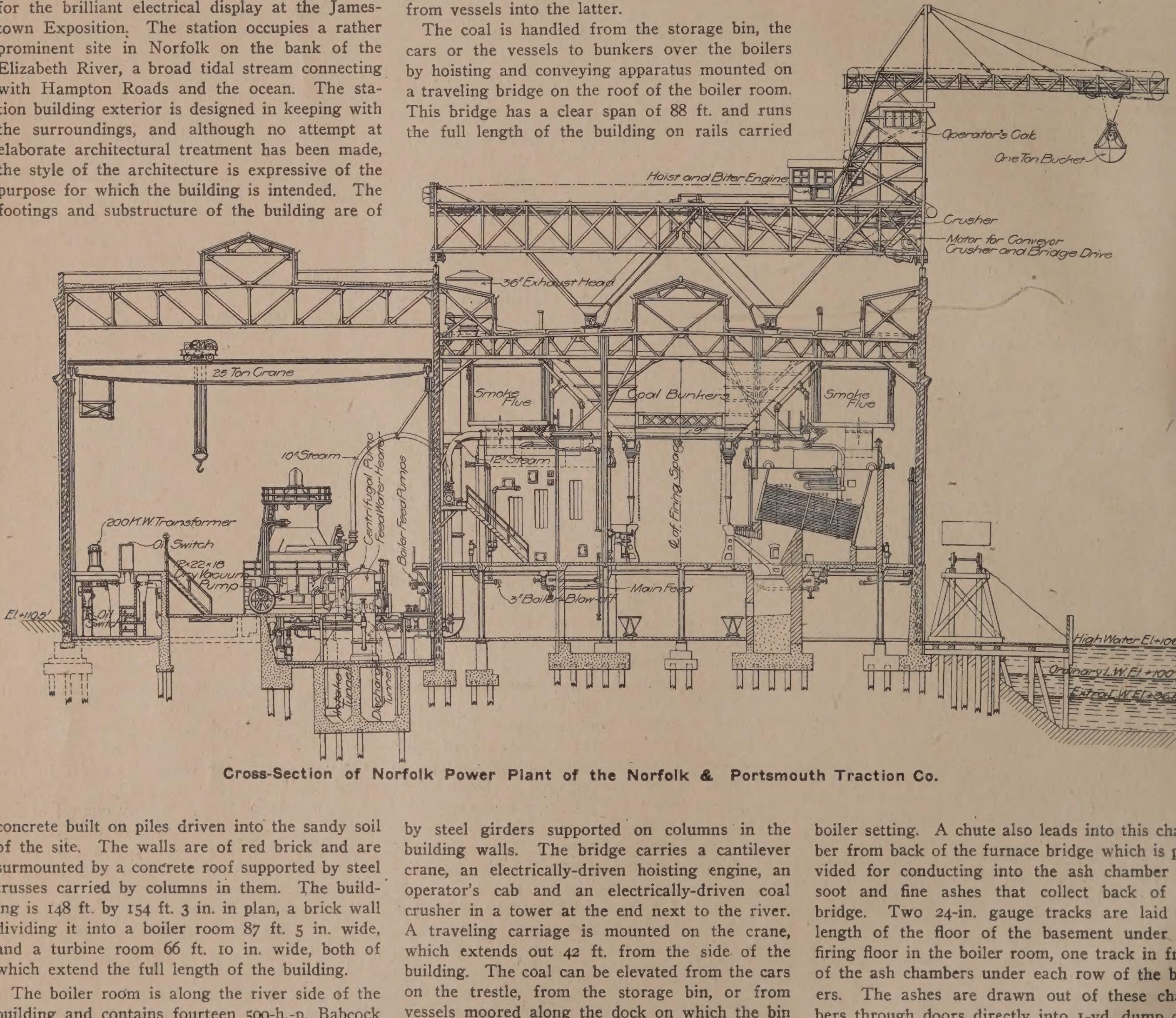
THE PANAMA CANAL SITUATION seems to be unnecessarily troubling a number of people having access to the columns of daily papers. The latter have been manifestly misled lately concerning the management of affairs under the new commission and the feeling of its leading subordinates. It has even been stated that the chairman of the commission was dissatisfied and wished to be relieved from his duties. While The Engineering Record has no knowledge of the opinions of Lieutenant-General Goethals concerning his work, it is in a position to state positively that there is no such marked dissatisfaction with conditions among the technical employees of the commission as recent published reports would indicate. Wherever many thousand men are engaged on an undertaking which necessarily compels them to go without some of the comforts to which they have been accustomed elsewhere, a certain amount of grumbling and a few cases of positive discontent must be expected. Fortunately most discontented people went home before the present commissioners assumed office, and those who are now there are thoroughly alive to the importance of their work and to the credit that all will receive in due measure from participation in the undertaking. It is true that there was some apprehension in the engineering staff when military engineers were placed in control of the commission, but this disappeared as soon as the men had an opportunity of becoming acquainted with their new leaders. There will always be differences of opinion between those engaged on the work, which may lead in some cases to resignations, but there has never been a time when the force of canal builders felt more satisfied with their conditions than at present. Where work can be pushed it is going ahead energetically; where investigation is necessary in order to avoid mistakes, it is being made; and where the data for plans are complete, the designs are being pushed. There is no ground for any other statements.

THE NEW YORK RAPID TRANSIT RAILROAD COMMISSION has passed out of existence but it has left behind it a record of good work very well done. In the face of all kinds of opposition and in spite of the apathy of the public for some years it blazed the way for improved transportation facilities in Greater New York. It built one great subway line, it partly built others, and it left plans by which the transportation needs of the city can be met for a good many years to come. It went about its work with great shrewdness. The technical features of designing its proposed works were entrusted to an engineer, Mr. William Barclay Parsons, who had been engaged in studies of the city's transportation needs for some years before the organization of the commission. When the blight of politics settled on its work, the latter was quietly stopped until a time arrived when it could be carried on with a decent regard for the interests of the taxpayers. Instead of asking what terms would be acceptable to possible bidders the commission prepared its own requirements and at last succeeded in making a contract with responsible people, which was a good one in view of the novelty of the undertaking. The first subway was a thing untried; it was essential to make no false step at any stage of its history, and so the Commission necessarily moved slowly, and only after a full deliberation of the probable result of each proposed act. And on account of this deliberation and the self-sacrificing public spirit of the members of the Commission, there have been no mistakes to check the progress of rapid transit and the city is to-day in full possession of detailed information concerning every feature of the subject. The Engineering Record considers the abolition of the Board a great mistake, provided its members could be persuaded to continue in office, but it must be admitted that the transit work now pressing for early execution is so extensive and varied that it would probably unduly tax men of such large affairs as the commissioners who have retired.

THE PUBLIC SERVICE COMMISSIONS which will exercise supervision of the railway and lighting companies in the State of New York are made up of men of high standing. Some of them have taken an active interest in party politics, but none are "politicians." Most of them are lawyers, but business, manufacturing and engineering are also represented. Whether these men are capable of team work cannot be foretold; if they are not then the famous plan of controlling public utilities devised by Governor Hughes will come a tremendous cropper, for the commissions replaced by the two new ones did fair work. The new commissions undertake their duties with a great handicap, from the fact that the same kind of control in different parts of the State is vested in two independent bodies, each with powers of making rules and regulations to govern the companies under its jurisdiction. If the New York Central & Hudson River Railroad Co. has to obey one set of regulations until it comes down to the New York City line, and then must obey a different set of regulations, is there any likelihood that this complication cannot be utilized by the company to nullify effectively any regulations it does not like? While the apointment of two commissions with equal powers, one for the city and the other for the State outside the city, may have been a good political move to secure the adoption of the general principle of centralized State control of public utilities, it seems a pretty severe tax on human nature to expect the two commissions to agree, even on the most important features of their work. It is therefore reasonable to expect that before long the two bodies will be consolidated, and the work of the consolidated commission will be arranged so that everywhere in the State the supervision of public utilities contemplated by the spirit of the legislation will be uniform and effective. Such supervision is desirable, both technically and as respects rates, but The Engineering Record has no expectation that it can be exercised successfully by two independent bodies.

THE POWER PLANT OF THE NORFOLK & PORTSMOUTH TRACTION CO.

The new electrical generating station of the Norfolk & Portsmouth Traction Co., at Norfolk, Va., with a capacity of 10,500 kw., made up of a 1,500-kw. and three 3,000-kw., turbo-generator units, is thoroughly modern in all the details of its design. This station will furnish power to operate the street railways in Norfolk and Portsmouth and a number of electric railways running from those cities to resorts along the shore of the Atlantic Ocean and arms of the latter; the traffic between the Jamestown Exposition grounds and Norfolk will also be handled entirely by electric lines supplied with power from this station. The latter will also furnish power for electric lighting in Norfolk and the adjacent cities and for the brilliant electrical display at the Jamestown Exposition. The station occupies a rather prominent site in Norfolk on the bank of the Elizabeth River, a broad tidal stream connecting with Hampton Roads and the ocean. The station building exterior is designed in keeping with the surroundings, and although no attempt at elaborate architectural treatment has been made, the style of the architecture is expressive of the purpose for which the building is intended. The footings and substructure of the building are of concrete built on piles driven into the sandy soil of the site. The walls are of red brick and are surmounted by a concrete roof supported by steel trusses carried by columns in them. The building is 148 ft. by 154 ft. 3 in. in plan, a brick wall dividing it into a boiler room 87 ft. 5 in. wide, and a turbine room 66 ft. 10 in. wide, both of which extend the full length of the building.



Cross-Section of Norfolk Power Plant of the Norfolk & Portsmouth Traction Co.

The boiler room is along the river side of the building and contains fourteen 500-h.-p. Babcock & Wilcox double drum water-tube boilers. These boilers are set in batteries of two each, the batteries being in two rows, with six boilers in one row and eight in the second. The two rows face on a firing floor having a clear width of 15 ft. at the level of the boiler room floor, the fronts of the boilers in the two rows being 27 ft. apart. The space over the firing room floor is open and is surmounted by a monitor in the roof having side windows and skylights; a monitor with side windows and skylights also extends the length of the building along both sides of the roof over the boiler room. This arrangement of monitors produces good light and secures ventilation for all parts of the boiler room.

The coal supply for the boilers can be delivered in cars on a switch track on a trestle along the river side of the building, or by vessels in the river. An open storage bin, 26 ft. wide and with its outer side 5.5 ft. high, is built on piles directly under the trestle. This bin is against the side of the building, extending the full length of that side and along one end of the latter. The floor of the bin is at the extreme high-water level in the river, while the base of rail on the trestle is 14 ft. above that level so the bin has a large storage capacity. The coal is dumped from the cars directly into the bin, or can be unloaded from vessels into the latter.

The coal is handled from the storage bin, the cars or the vessels to bunkers over the boilers by hoisting and conveying apparatus mounted on a traveling bridge on the roof of the boiler room. This bridge has a clear span of 88 ft. and runs the full length of the building on rails carried by steel girders supported on columns in the building walls. The bridge carries a cantilever crane, an electrically-driven hoisting engine, an operator's cab and an electrically-driven coal crusher in a tower at the end next to the river. A traveling carriage is mounted on the crane, which extends out 42 ft. from the side of the building. The coal can be elevated from the cars on the trestle, from the storage bin, or from vessels moored along the dock on which the bin stands by a 1-ton clam-shell bucket swung by a hoisting cable from the traveling carriage.

The clam-shell bucket dumps into a hopper at the inner end of the crane. A chute leads from this hopper to the coal crusher immediately under it, the crusher discharging on a belt conveyor inclined upward toward the top of the traveling bridge and extending to the middle of the latter; the crusher may be by-passed and coal discharged from the hopper directly to the conveyor. Gates are arranged at the end of the conveyor so the latter will discharge at the middle of the bridge into either or both of two inclined chutes leading down to openings in the roof of the boiler room. These chutes are each fitted at the lower end with an undercut gate controlled from the operator's cab. Coal is supplied by these chutes to two rows of bunkers over the fronts of the boilers, each boiler having a separate bunker with a capacity of 95 tons. An opening in the roof, normally covered with a tight hatch, is provided over each of the bunkers, which are fed through these openings by the chutes on the traveling bridge. The bunkers are carried by steel columns in the fronts of the boiler settings and by the roof trusses. A vertical chute controlled at the top by a gate operated from the firing room floor feeds coal from each bunker to the charging hopper of the stoker immediately under it.

The ashes from each stoker are discharged into a tight chamber directly under the front of the boiler setting. A chute also leads into this chamber from back of the furnace bridge which is provided for conducting into the ash chamber the soot and fine ashes that collect back of the bridge. Two 24-in. gauge tracks are laid the length of the floor of the basement under the firing floor in the boiler room, one track in front of the ash chambers under each row of the boilers. The ashes are drawn out of these chambers through doors directly into 1-yd. dump cars running on these tracks. These cars are pushed out of the building by hand to low ground around the station on which the ashes will be dumped for filling.

The setting and arrangement of the boilers do not involve any unusual features. The boilers are designed to operate at 195 lb. pressure and are each equipped with superheaters capable of raising the temperature of the steam to 150° Fahr. above the temperature of saturated steam. Two brick stacks, 12.5 ft. in diameter and 200 ft. high above the boiler room floor, are built on separate concrete footings at one end of the building, each stack serving one row of boilers. A smoke flue built of riveted steel plates extends through the entire length of the boiler room from each of the stacks and is swung over the rear of the boiler settings from the steel roof trusses. Each boiler is connected to one of the flues by a short vertical breeching.

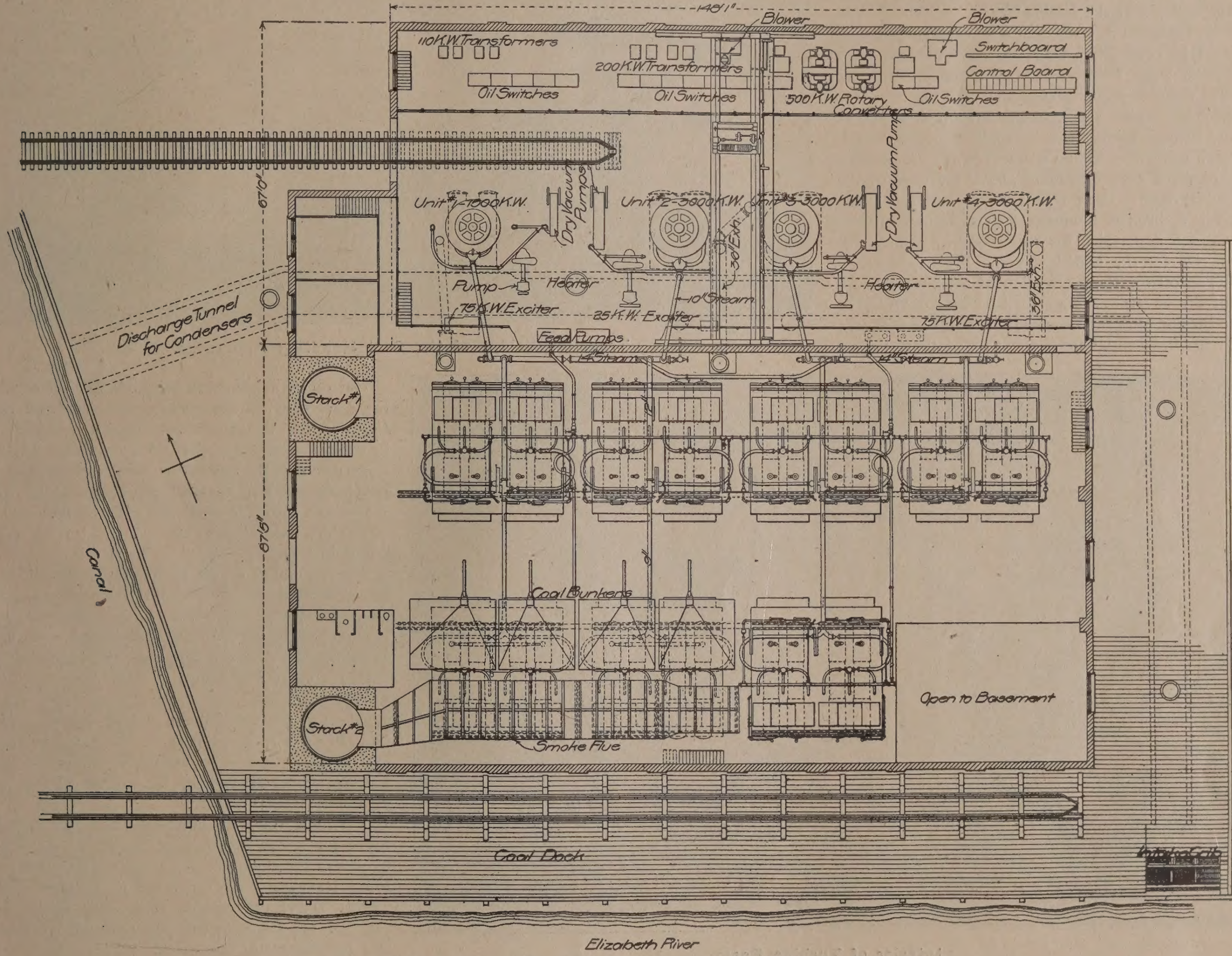
Two pairs of 18x12x24-in. Atlantic type upright Dean Bros. feed-water pumps and two Alberger feed-water heaters, with 2,500 sq. ft. of heating surface each, are installed in the turbine room, one pair of pumps and one heater forming a set. The four main units in the turbine room are all operated condensing. A separate hot well is provided to receive the discharge from the condenser of each unit, an 8x12x12-in. Alberger vertical pump being installed at each of these wells to deliver the condensed steam to the feed-water heaters; these pumps may also discharge into the tunnel under the turbine room basement. Make-up water is supplied to the heaters from a connection with the city mains, and a second connection with those mains is provided so the heaters may be supplied entirely with cold water, if necessary. The steam-consuming units of the auxiliary equipment in the station discharge their exhaust steam into the feed-water heaters.

The boiler-feed pumps can draw either from the feed-water heaters, from a condenser discharge tunnel under the engine room, or from the city mains. Each pair of pumps supplies a separate system of feed-water piping for the boilers, the two systems being interconnected so any pump can supply either row of boilers. A 4-in. main feed-water header, hung from the ceiling of the basement under the boilerroom is provided for each row of boilers. These headers are supplied through a connection from both sets of pumps, each boiler having a connection with the header under its row. An auxiliary header is extended over each row of boilers, these two headers being interconnected and supplied independently from the feed pumps.

A 14-in. steam header in two sections is supported on the wall between the engine room and boiler room, the two sections being connected by an 8-in. loop. Two 12-in. branches are extended from each section of the steam header to connections with the first row of boilers and are then continued as 9-in. lines to the second row of boilers. The two drums of each boiler have a 6-in. connection with one of these branches, the connections each having a check and stop valve and an angle valve at the boiler, and a gate valve at the header.

Two of the main units in the turbine room are supplied from each of the two sections of the header, the latter having a valve at the middle by which either half of it may be operated independently. A line is extended into the turbine room basement from both ends of each section of the header to supply the auxiliaries in the turbine room, all of which are steam driven.

Extra heavy hydraulically-operated Crane gate valves are used on the steam headers and on the main connections from them. These valves are arranged to be operated from the basement of the boiler room. Water under pressure for operating the valves is obtained from connections to the supply lines leading from the feed-water pumps to the boilers, auxiliary connections also being provided. These connections are each controlled by a four-way cock, the controlling cocks being brought together in two groups on the wall of the boiler-room basement so the operator may close all of the valves on one section of the steam header and on the branches of the latter leading to the main units in the turbine room, without moving from the group of controlling valves. All the fittings and valve bodies on the main live steam connections are of cast-steel.



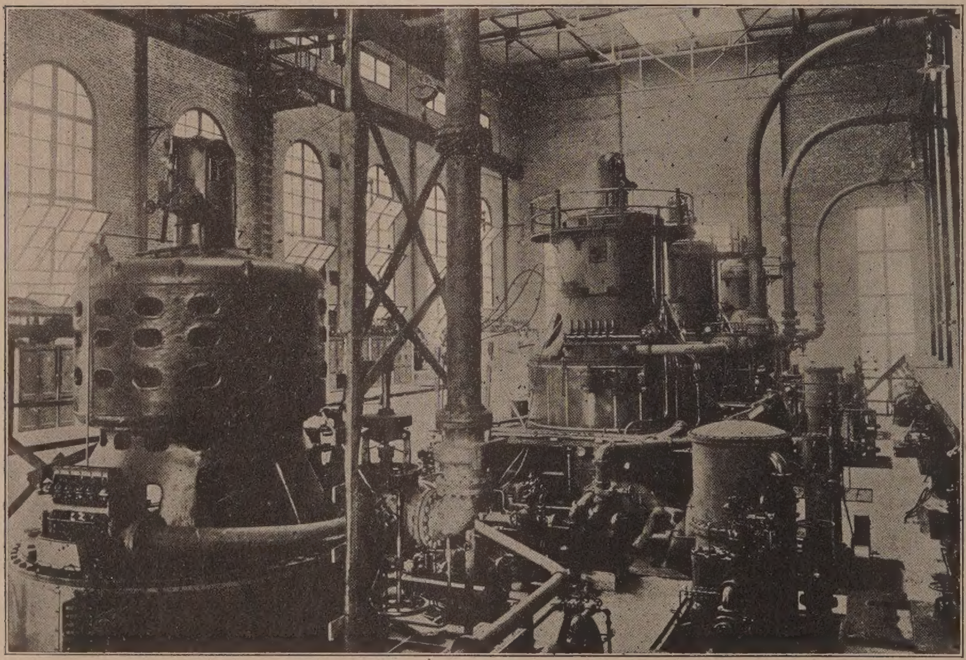
Plan of Norfolk Power Plant of the Norfolk & Portsmouth Traction Co.

The four main units in the turbine room are in a single row, the 1,500-kw. unit being at the front end of the station. Between this unit and the first 3,000-kw. unit are the condenser equipments for these two units, one feed-water heater and a pair of feed pumps. The third and fourth units are arranged in a similar pair with their auxiliaries between them. The plans for the station contemplate that the building will be extended from the end which the fourth unit occupies.

The four main units have three-phase, 60-cycle, 11,000-volt, 10-pole alternating-current General Electric generators, which are each direct-connected to a Curtis turbine, and are operated at 720 r.p.m. The steam supply to these turbines is automatically controlled by an oil-operated governor in each case. The turbines all have base-condensers of the Alberger type, those on the 3,000-kw. units having 12,000 sq. ft. of surface, and the one on the 1,500 kw. unit having 6,000 sq. ft. of surface. Cooling water for these condensers is obtained from a large tunnel which connects with the river and extends the length of the building under the floor of turbine room basement. Three 20-in. Alberger volute centrifugal pumps, each direct-connected to a steam engine, are placed on the turbine room floor, one close to each of the large units, which deliver water from the intake tunnel to the condensers. A 16-in. Alberger volute centrifugal pump performs the same service for the condenser of the 1,500-kw. unit. After the circulating water has passed through the condensers it is discharged into a second tunnel, which parallels the intake tunnel and is also connected with the river, the two tunnel connections being at nearly diagonally opposite corners of the station site.

A 12x22x18-in. Alberger dry vacuum pump is used in connection with the condenser of each of the large units and an 8x20x12-in. Alberger dry vacuum pump serves the condenser of the 1,500-kw. unit. These pumps are on the floor of the turbine room, close to their respective units. Each condenser has an exhaust to the atmosphere through a riser extending above the roof of the boiler room. Each free exhaust outlet is fitted with a bronze mounted Davis turbine relief-valve, a 24-in. size for the 3,000-kw. and an 18-in. size for the 1,500-kw. unit.

The oil for the lubrication of the turbines and for the governors is supplied by four 9x5⅛x3⅛x10-in. duplex, center-packed plunger Blake pumps of the differential type, one pair of these pumps supplying two turbines. These pumps take suction from a pipe supplied from the storage chamber of an oil filter in the basement, to which the oil from the bearings of the turbines is returned by gravity. The connections between the pumps and the bearings is arranged so either pump of a set may supply either turbine in each pair.

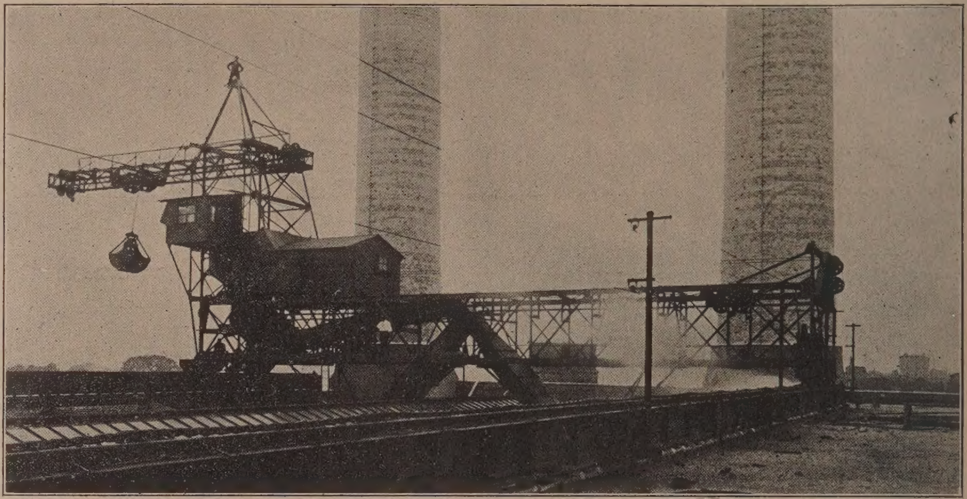


Interior of Turbine Room.

A 25-kw. and two 75-kw., 4-pole, 125-volt direct-current General Electric generators furnish excitation for the main generators. These exciters are each direct-connected to a horizontal Curtis steam turbine and operate at 2,400 r.p.m.

A part of the output of the alternating-current generators is transformed by two 500-kw. General Electric rotary converters in the engine room to direct current at 550 volts and is transmitted at that voltage for use on the street railway lines in the immediate vicinity. A large part of the remainder of the output is transmitted at 11,000 volts to sub-stations where it is transformed by rotary converters to direct current at 600 volts. The balance is stepped down to 2,300 volts alternating current and is used to supply lighting circuits.

The transformers, converters, control board, switchboard and so forth, are mounted on a concrete platform, 17 ft. 8 in. wide, which extends the length of the engine room, 8 ft. above the level of the floor of that room. The three cable leads from each main generator are carried under the engine floor in conduits to current transformers under the platform and then to motor-operated automatic 11,000-volt General Electric oil switches mounted on the platform. These switches are connected through disconnecting switches to three-phase buses in a brick compartment under the space enclosed by the platform and the wall in front of the latter. Each bus is in a separate section in this brick compartment. The buses are sectionalized at the middle by a 11,000-volt motor-operated oil switch, two generators being on each section. Three 11,000-volt feeder lines lead out of the station from each section of the bus-bars. Leads also extend from one section of the buses through disconnecting and oil switches to the primaries of two 550-kw., three-phase General Electric air-blast transformers mounted on the platform. The 11,000-volt current is stepped down to 420 volts by these transformers which deliver it to the rotary converters. The current used for lighting is stepped down to 2,300 volts by three 200-kw. and three 100-kw. single-phase delta-connected transformers, motor-operated oil switches and disconnecting switches being provided between the 11,000-volt buses and the transformers, and solenoid-operated oil switches and disconnecting switches between the transformers and the 2,300-volt buses.



Traveling Bridge of the Coal Handling Apparatus.

The oil switches, rheostats, field switches and the governors of the main generators and the switches for the 11,000-volt lines are operated by remote control switches on a switchbaord having 110 volts at the latter. This board has a panel for each generator, a tie panel for the 11,000-volt buses, a panel for each of the rotary converters, two transformer panels and six outgoing line panels.

The regulation of the auxiliary equipment, the direct-current side of the rotary transformers and 600-volt feeders, the local power and lighting circuits and so forth is controlled from a second switchboard. This board has two panels for Tirrill voltage regulators, a panel for each of three exciter units, a station lighting panel, four panels for 600-volt, direct-current feeder lines, two panels for the positive of the direct-current side of three rotary converters, a 600-volt panel for power supply around the station and three 2,300-volt feeder panels.

A switch track is extended into the engine room for a car length to expedite the delivery of heavy machinery. A 25-ton Niles-Bement-Pond traveling crane operated by three electric motors spans the turbine room and serves all parts of the latter, permitting of ready removal and installation of apparatus.

The station was designed and built under the direction of Sargent & Lundy, consulting mechanical and electrical engineers of Chicago. Messrs. J. B. McAfee, C. O. Emmons and E. C. Hathaway form an engineering committee in charge of the design and construction of the station for the Norfolk & Portsmouth Traction Co. The electrical equipment of the turbine room was furnished and installed by the General Electric Co.

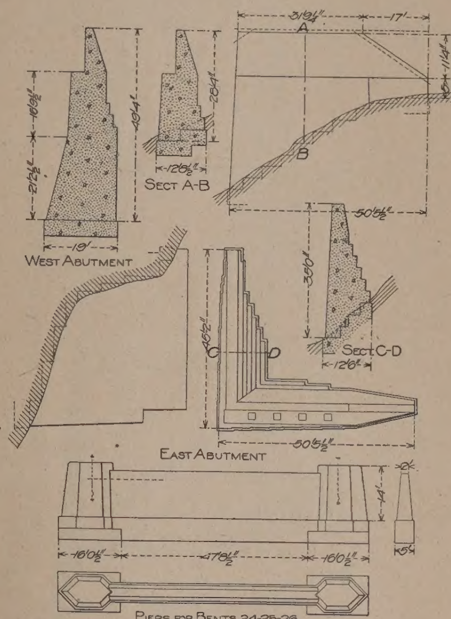
An Exhaust Steam Turbine of the Rateau type at the Zollverein mine in the Essen coal district of Germany was found to require from 18.6 to 14.3 kg. of steam per kilowatt-hour when developing from 433 to 1,112 kw. The steam was supplied at 1.004 to 1.155 atmospheres absolute and the vacuum was 93.46 to 88.29 per cent. at the limits mentioned.

The Moodna Creek Viaduct, Erie R. R.

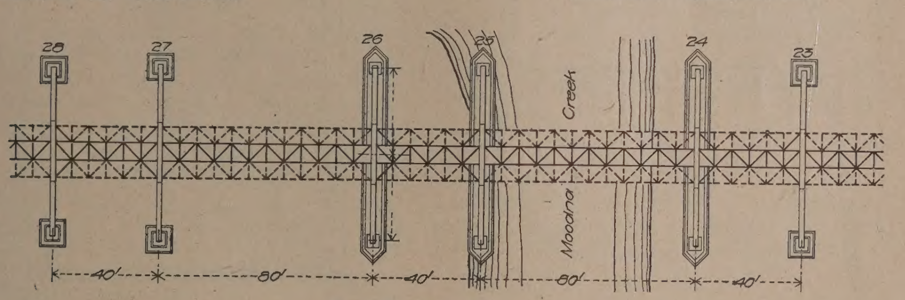
The Erie & Jersey R. R. now under construction is a 39-mile branch of the Erie system running from Highland Mills, N. Y., to Guymard, N. Y., and crossing the Moodna Creek valley on a tangent at a 2 per cent grade, on a steel viaduct 3,200 ft. long and 181.47 ft. above high water made of alternating 40 and 80-ft. plate girder spans supported by 40-ft. steel towers 120 ft. apart on centers. The substructure and towers are designed for a double-track superstructure but only enough girders for the single track will be erected at first, provision being made for the erection of the girders for the second track and for the reinforcement of the towers to carry the additional load at any future time without seriously increasing proportionate expense.

Careful estimates were made of the comparative cost of placing the reinforcement in the tower columns, now, and of deferring it until some future time, which showed that, calculating interest at 5 per cent., an economy will be effected if the reinforcement is deferred eight years or more.

The substructure is entirely of concrete without reinforcement and comprises two abutments, three intermediate piers and 98 separate pedestals for the tower columns. The footings were carried down from 5 to 10 ft. below the surface of the hard clay soil and were proportioned to load it to a maximum intensity of 5,000 to 6,000 lb. per square foot. At the west end the abutment 50 ft. high above the original surface of the ground is of the "pulpit" type without wings, and is 19 ft. wide at the base and 37 ft. long perpendicular to the bridge axis. The upper part is carried up 12 ft. above the bridge seat to form a back wall retaining the fill and the front and rear faces are battered and offset as indicated in the cross-section.



Details of Substructure.



Part Plan of Viaduct.

At the east end of the viaduct the surface of the ground slopes both longitudinally and transversely, and the abutment is L-shaped in plan with one long wing wall. The footings for both the wing wall and the face are built in offset horizontal courses on solid rock.

At the deepest part of the valley, where the viaduct crosses the Moodna Creek, three of the tower bents are located in or near the bed of the creek, and in order to protect their foundations from flood and drift and ice, the special hexagonal pedestals under both columns of each bent have sharp cut-waters up and down stream and are connected by a solid vertical wall 2 ft. thick at the top and 12 ft. with a base 5 ft. wide extending down to the bottom of the footings and made integral with them so as to form a long and solid pier approximately parallel to the creek, developing great longitudinal strength and preventing any driftwood or debris from lodging between the pedestals.

In all of the other tower bents each column has a separate and independent pyramidal pedestal 5 ft. square on top with battered sides, seated on two or three offset courses extended to a width of 11 to 12 ft. At the ends of the viaduct where the tower weights are a minimum the sides of the tops of the piers are reduced to 4½ ft. Where the distance from the base of the column to the surface of the ground is 5 ft. or less the height of the pedestal above the footing is 5 ft. In all other cases it is 8 ft. Each pier is provided with two vertical anchor bolts 2 in. in diameter and 10 or 12 ft. long, embedded in the masonry and projecting about 20 in. above its top. A shallow U-shaped bend is made in the bolt 2 ft. above the bottom, to prevent it from turning in the masonry and each end is provided with a nut and 6 in. of thread. The concrete was made 1:2½:5 with Atlas Portland cement and all exposed edges of piers, bridge seats and wing walls were rounded to a 3-in. radius.

The superstructure of the viaduct consists of twenty-seven 80-ft. spans and twenty-six 40-ft. spans supported on 52 transverse trestle bents, longitudinally braced together in pairs to make 26 towers, 40 ft. long, 19½ ft. wide at the top on centers, with the columns battered 1½ in. per ft. to a maximum width of about 65 ft. at the foot of the tallest towers. The towers are from about 35 to 180 ft. high and are divided into one to five stories with X-braced panels. Both columns of each bent are riveted at the top between the webs of a transverse box plate girder 10 ft. deep, with its top flange flush with the top flanges of the longitudinal girders. The upper panel has a uniform depth of 42 ft. in all bents except the single story ones, and the intermediate panels have a uniform depth of 30 ft. on centers, while the heights of the lower panels vary from 20 to 45 ft., according to the irregularities of the surface.

The columns have a 23½x26¼-in. open rectangular cross-section, made of two built-up channels having their webs parallel to the axis of the viaduct and their flanges turned inward and latticed. Wide rectangular plates riveted across the flanges of the columns project beyond the inner faces and form jaw plates receiving the field-riveted connections of the transverse struts and diagonal members. Each web has from end to end a double row of open rivet holes provided for the future connection of an I-shaped diaphragm perpendicular to them which will be made with 22x⅜-in. flange angles, and two 7x⅝-in. flange cover plates field-riveted in the interior of the columns when it is decided to reinforce them in order to withstand the extra stresses from the added track. The cross-section of the column varies in the different stories, as indicated on the general elevation.

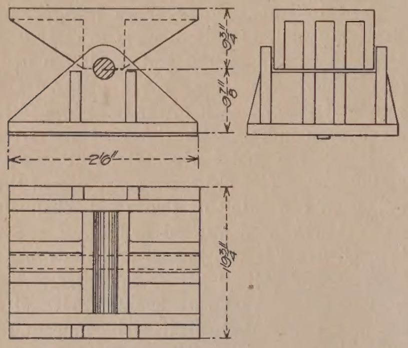
In the high bents the transverse width at the bottom is so great that the temperature movements make it necessary to provide a roller bearing, similar to that of an ordinary bridge truss, for the foot of one column, the opposite column being seated on a fixed pedestal. The horizontal transverse struts are built channels having their webs horizontal and their flanges turned inward and latticed. The X-braces are pairs of angles latticed together, one member being continuous in each panel and the other cut to clear it at their intersection and spliced and connected to it with two field-riveted flange cover plates. The longitudinal face of each tower is X-braced in panels corresponding with those of the transverse face but has no horizontal strut except one at the foot. The X-braces are uniform throughout, each consisting of two 12-in. channels with vertical webs and latticed flanges. One of them in each panel is continuous and the other is cut to clear and spliced across the intersection with web plates. The struts are field-riveted at the ends to pairs of vertical web-connection plates shop riveted to the columns.

The single-track viaduct, as first erected, has two lines of longitudinal girders each 3 ft. 3 in. from the axis of the viaduct. Provision is made for adding two more duplicate lines of girders, each 6½ ft. beyond the original line, when it is decided to double-track the viaduct. The 40-ft. girders, about 5½ ft. deep over all, are all fixed at both ends where they are field-riveted to the transverse girders at the tops of the towers. The 80-ft. girders, 9 ft. deep, are similarly connected to the tower girders at the fixed ends. Expansion bearings are provided for the 80-ft. girders on both abutments and at one of every second span, making a series of portals at intervals of 240 ft. where they have sliding seats on planed bed plates. The transverse tower girders have deep web pockets to receive the sliding ends at the expansion points.

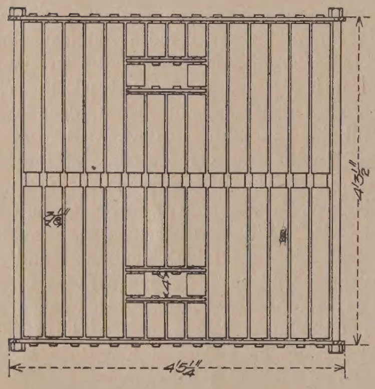
The upper ends of the top sections of the columns have very deep and wide flange cover plates, projecting a considerable distance from the inner face of the column, which in reality form the end sections of the webs of the transverse girders and are field-riveted to outside cover splices shop-riveted to the latter. This arrangement greatly simplifies the construction and facilitates the erection, allowing the location of all field-driven rivets in accessible positions. The center sections of the transverse girders are 13 ft. long and are shop-riveted complete to the webs and are connected by the top flange cover plates and by vertical longitudinal diaphragms in the planes of the longitudinal girders. The fixed and expansion end middle sections weigh 9,100 lb. and 13,800 lb. respectively, and are found to be easily handled and assembled in the field. The diaphragms are provided with manholes to make the interior of the header girders accessible for painters and inspectors after erection. The fixed ends of the longitudinal girders are field riveted to the webs of the transverse girders with 42 rivets each, driven from the outside with pneumatic hammers, sufficient space being provided betwen the webs to hold up against the heads of the rivets. The top flanges of adjacent longitudinal girders are connected across the transverse girders by cover plates field-riveted to all three girders except where they are bolted through slotted holes to the expansion ends of the sliding girders.

The longitudinal girders are braced together with transverse angle frames, top lateral struts and zig-zag angles, thus making horizontal wind trusses 6½ ft. deep on centers and 40 and 80 ft. long. In order to transmit the horizontal shear at the ends of the span to the tops of the tower columns without producing a bending moment in the transverse girders, the end transverse struts are spaced about 4½ ft. beyond the transverse girders and the lateral angles terminating there connect with horizontal knee-braced struts running directly to the column tops. These struts will be removed when the viaduct is double-tracked and an additional set of lateral bracing is put in on each side of the two center girders, as indicated by dotted lines on the plan diagram.

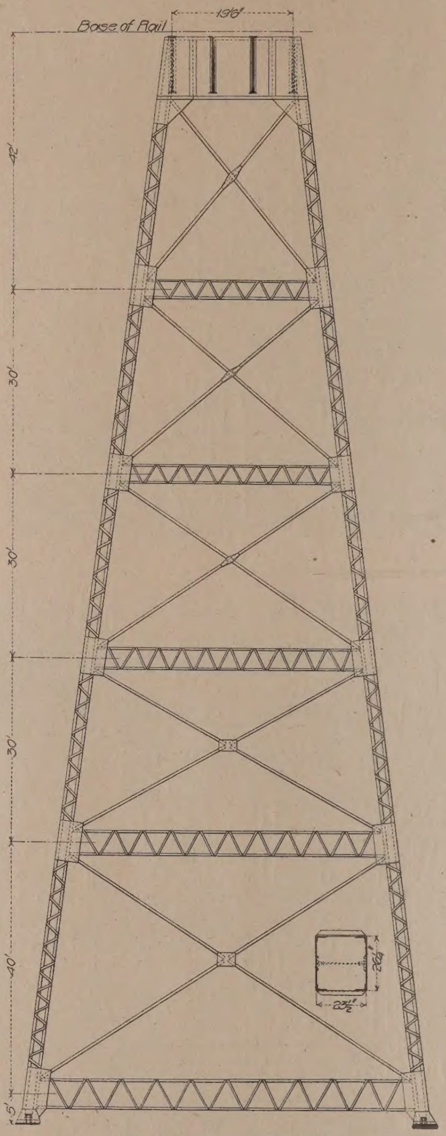
Cross ties 10 in. deep and 16 in. apart on centers are laid on the top flanges of the stringers, to which every fourth one is hook bolted at both ends. Every fourth tie is 16 ft. long with a projection beyond one side of the track to carry a 5-ft. sidewalk with 2x9-in. longitudinal plank 16 ft. long. The ends of the long ties carry a wooden lattice girder hand-rail 4 ft. deep with a 5x5-in. vertical posts 8 ft. apart securely bolted to the ends of the ties. The intermediate ties



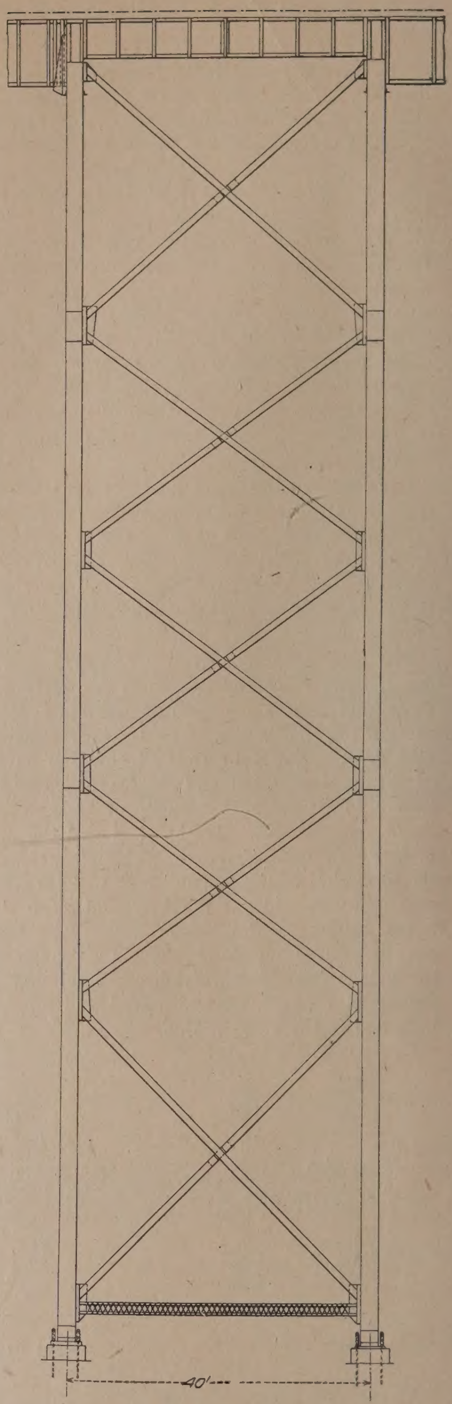
Abutment Expansion Bearing.



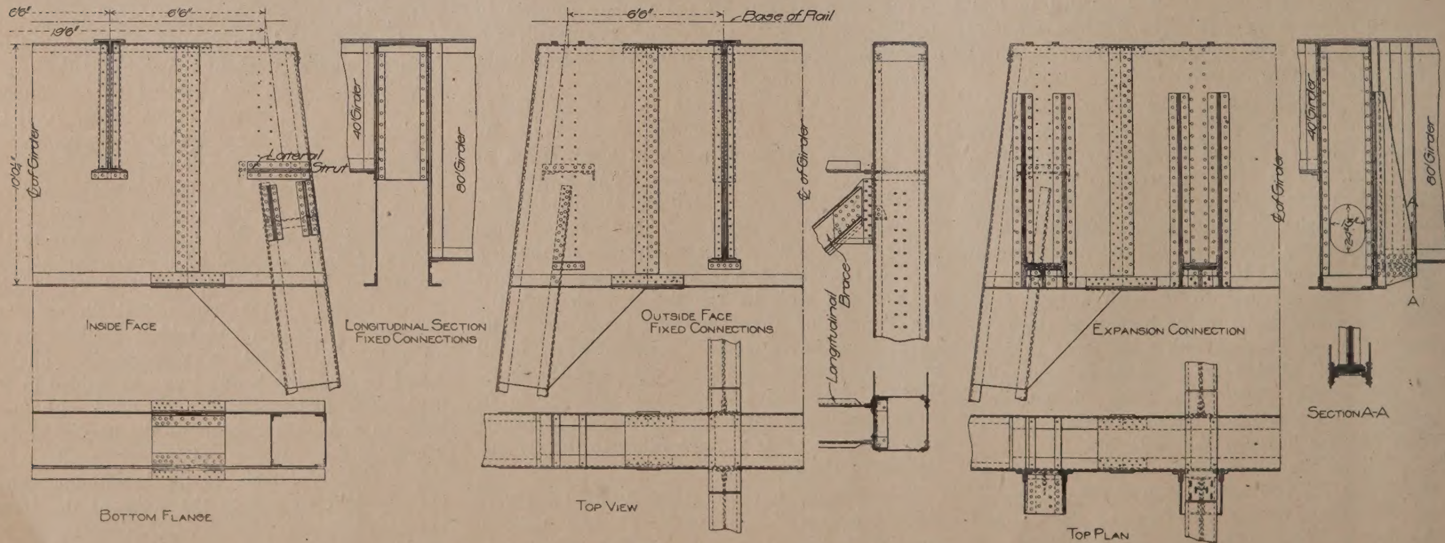
Rollers under Column.



Transverse Elevation.



Longitudinal Elevation.



Connections of Longitudinal and Transverse Girders.

are 10 ft. long and every other one is bolted to the 5x8-in. guard timbers. All high viaducts on the Erie Railroad have wooden hand rails as the appearance of their heavy lines is considered better than that of a lighter construction. An effort is always amde to accentuate the columns and the top line of the structure and to simplify the bracing, so that the main supporting elements may not be confused by a network of insignificant members.

The tower girders are 38 ft. 10½ in. long over all and their webs are two ⅜-in. plates 108 in. deep, shop-spliced with four rows of rivets in a pair of cover plates. The flanges are made of a pair of 6x6x⅝-in. angles and three 16½-in. cover plates, one of them full length. Pairs of 5x3½x⅜-in. angles with fillers divide the girders into 6½-ft. panels.

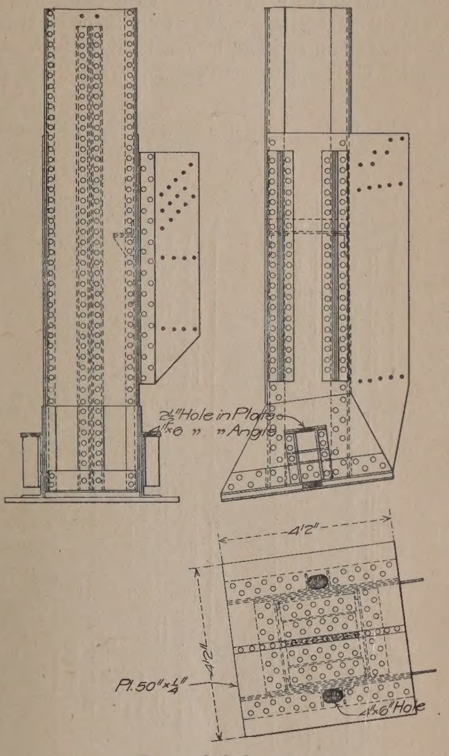
The transverse girders have 120x⅜-in. single-piece web plates 26¼ in. apart in the clear with 6x6x⅝-in. bottom flange angles. The 6x4x⅝-in. top flange angles have their horizontal flanges turned inward to clear the longitudinal girders and are shop-riveted to the 27x⅜-in. cover plates. At the ends of the fixed longitudinal girders the webs are connected by diaphragms 62½ in. deep in the planes of the longitudinal girder webs. At the expansion connections the diaphragms are extended to the full depth of the girder between flange angles, to reinforce thoroughly the pocket connections and are provided at the bottom with 18x24-in. manholes to give access to the center part for inspection, painting and riveting. The expansion bearing pockets are made of a pair of 20x⅝-in. vertical longitudinal plates 8 ft. long shop-riveted to the webs and having at the bottom an 18¼x20½-in. reinforced horizontal shelf plate with a planed upper surface to receive the lower flange of the longitudinal girder.

The feet of the tower columns have 4 ft. 2 in. x 3 ft. 9 in. base plates stiffened by vertical transverse flange plates and heavy connection angles, and provided with two 4x6-in. slotted holes just clear of the column faces. These holes receive the 2-in. anchor bolts that pass through pockets made by vertical distributing angles on the faces of the columns and through 2¼-in. holes in horizontal shelf angles fitted to the tops of the vertical angles and affording bearings for their nuts. The fixed column base plates are seated directly on the carefully dressed masonry, but the bases of the expansion columns are seated on nests of fifteen 3⅛-in. rollers 50 in. long with shoulder bearings in ordinary guide frames and center slots for guide ribs on the bottoms of the base plates and on the tops of the 50x50x1¼-in. bed plates. Four rollers in the center of each nest are made in three lengths each, with 4-in. spaces between the ends of adjacent sections of the same rollers to provide slots clearing the anchor bolts. The expansion ends of longitudinal girders have sliding bearings on all towers, but at the abutments they are provided with Standard cast-iron shoes and pedestals and the latter are seated on nests of eight 3⅜-in. rollers 22 in. long.

The superstructure contains about 4,042 tons of steel for the single track and 1,750 tons additional are required to transform it to a double-track structure.

In the present construction of the viaduct the two lines of longitudinal girders are spaced close together for a single track and are connected to the transverse or header girders near the centers of the latter. After the future double-tracking of the structure, the addition of the two outer lines of girders will very much increase the width of the roadway platform and extend it to the tops of the tower columns, thus directly transmitting to them the various horizontal stresses at track level. Meantime, in order to provide for the longitudinal traction stresses, the first panel point of each long span is braced with a heavy transverse cross strut and from its ends diagonal struts are run to the tops of the towers, as indicated in the general plan, thus directly connecting the main girders with the columns and providing for the transmission of the stresses through the tower bracing to the ground.

The Erie Railroad construction department is under Mr. J. M. Graham, vice-president, and Mr. Francis Lee Stuart, chief engineer, under whose direction the viaduct, including the foundations, was designed by Mr. Mason R. Strong, engineer of bridges and buildings, with the assistance of Mr. F. A. Howard, assistant engineer of bridges and buildings. The erection is being done by the bridge and building department under the charge of Mr. W. H. Wilkinson, inspector of bridges. The steelwork was fabricated by the McClintic-Marshall Construction Co.



Foot of Column.

Bituminous Preparations for protecting structural steel were strongly recommended by Mr. Bertram Blount at the British Engineering Conference last month. Natural bitumen is permanent but costly; coal tar boiled so that the coating shall be neither brittle nor sticky, is almost as durable and is cheap enough. Its use is limited by aesthetic considerations, but as these are chiefly based on convention, Mr. Blount believes that the engineer who insists on finishing a bridge with tar may be regarded as a poineer in the art of embellishment. Until that time bituminous materials can be freely used for all structures not too conspicuous. Where the work is exposed to boiler-gases, such as overhead bridges and station roofs, complete coating with a good layer of hot bitumen, he believes to have so much practical advantage over paint that no question of appearance should be permitted consideration. Whether paint or tar is used, the metal should be thoroughly cleaned from scale and rust immediately before the coating is applied. For structural steelwork, such as the frames of buildings or frame foundations, there is no preservative so good as lime or cement concrete, Mr. Blount said. It is essential that the concrete hould be dense and rich in cement, and that the cement or lime should be unexceptionable. Steel protected in this way need not first be cleaned from scale and rust.

Standard Test for Fireproof Floor Construction.

Reported by the Committee on Fireproofing Materials of the American Society for Testing Materials.

The test structure may be located at any place convenient to the applicant, where all the necessary facilities for properly conducting the test are provided. The test structure may be constructed of walls of any material not less than 12 in. thick, properly buttressed on all sides. The floor construction to be tested shall form the roof of the test structure. At a height of not less than 2 ft. 6 in., nor more than 3 ft. above the ground level, a metal grate, properly supported, shall be provided, covering the whole inside area of the building. In the walls below this grate level, draught openings shall be provided, as many as possible, furnishing openings with an aggregate area of not less than 1 sq. ft. for every 10 sq. ft. of grate surface. Means for temporarily closing these openings should be provided. In the wall, immediately above the grate level, a firing door, 3 ft. 6 in. by 5 ft. high, must be provided in the side of the building at right angles to the floor beams. A second door must be added when the span of the floor slab under test exceeds 10 ft.

Flues should be supplied at each of the corners, and oftener in case of a test structure exceeding 250 sq. ft. of grate surface, with sufficient opening to insure a proper draught, securely supported and disposed at the sides of the structure in such manner as not to rest on the floor under test.* In no case should a flue area be less than 180 sq. in.

The horizontal dimensions of the test structure will depend upon the number and the span of the systems under consideration. The clear span of the floor beams is to be 14 ft. The distance between floor beams, or span of slab, may be varied according to the design of the system to be tested, and should be as near as possible to usual practice. The underside of the construction under test must be not less than 9 ft. 6 in. nor more than 10 ft. above the grate level.

The construction to be tested should be designed for a working load of 150 lb. per square foot, and no more. This load to be uniformly distributed without arching effect, and to be carried on the floor during the fire test. The floor may be tested as soon after construction as desired, but within forty days. Artificial drying will be allowed if desired. The floor is to be subjected to the continuous heat of a wood fire, averaging not less than 1,700° F. for four hours.

The heat obtained shall be measured by means of standard pyrometers, under the direction of an experienced person. The type of pyrometer is immaterial so long as its accuracy is secured by proper standardization. The heat should be measured at not less than two points when the main floor span is not more than 10 ft., and one additional point when it exceeds 10 ft. Temperature readings at each point are to be taken every three minutes. The heat determination shall be made at points directly beneath the floor so as to secure a fair average.

At the end of the heat test a stream of water shall be directed against the underside of the floor, discharged through a 1⅛-in. nozzle, under 60 lb. nozzle pressure, for ten minutes.

After the floor has sufficiently cooled the load on the same shall be increased to 600 lb. per square foot, uniformly distributed.

The test shall not be regarded as successful unless the following conditions are met: No fire or smoke shall pass through the floor during the fire test; the floor must safely sustain the loads prescribed; the permanent deflection must not exceed one-eighth inch for each foot of span in either slab or beam.

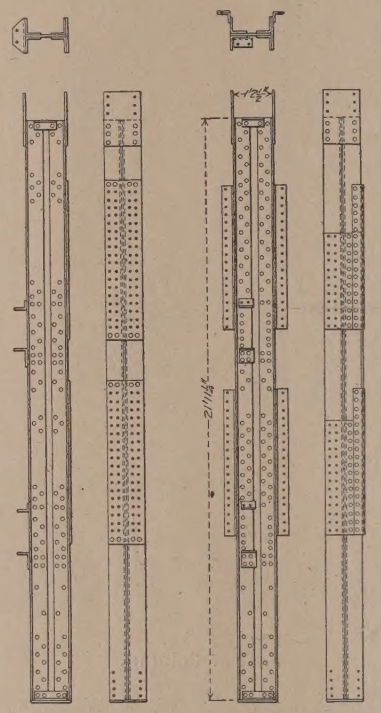
The Berger Building, Pittsburg.

The 60x90-ft., 15-story Berger Building at the corner of 14th Ave. and Grant St., Pittsburg, Pa., is an example of extremely simple and regular construction of a steel cage office building of moderate height. The plan is a parallelogram with the ends skewed 11⅛ inches on the long side. This difference is all concentrated in the end panels of the floor, so that the 12 intermediate panels are rectangular, and the six in the center of the building are all 15 ft. wide and 16 ft. long, the others varying from 15 ft. to 20 ft. 1½ in. From the basement to the fifteenth floor inclusive the beam framing is the same in each story, and is of the simplest possible description, consisting of single longitudinal and transverse I-beams on the center lines of the columns except for the wall girders which are riveted on the outer faces of the columns, and having no intermediate beams or girders whatever except in the two intermediate panels containing the elevator and stair-well. The main beam, therefore, supports the Johnson system floor arches, made with 6-in. blocks and a maximum span of 15 ft., and are proportioned for a dead load estimated at 65 lb. per square foot, and for a live load of 100 lb., on all but the roof, which is proportioned for dead and live loads of 65 lb. and 60 lb. per square foot respectively. The I-beams vary from 7 in. 15 lb. to 15 in. 60 lb., and in all cases are connected to the column with simple top and bottom horizontal flange angles.

The columns are made in two-story lengths, except in the upper section, which are three stories long. All wall columns are spliced 5½ ft. and all interior columns 11¾ in. above finished floor level. The first story is 16 ft. high and those above it are uniformly 11 ft., except the fifteenth story which is 16½ ft from the floor line to the highest point of the roof. This gives the roof a total height of 175 ft. above the first floor or 200 ft. above the sub-basement floor. All columns have an I-shaped cross-section made with two pairs of flange angles and a web plate. The lightest column section is made with four 5x3½x5/16-in. angles and a 14x5/16-in. web plate about 36½ ft. long and extends through the thirteenth, fourteenth and fifteenth stories and supports the main roof. The heaviest column section is proportioned for a static load of 554,000 lb. plus wind stress, and is made with four 6x6x¾-in. angles, one 14x¾-in. web plate and four 14x½-in. cover plates and is 30 ft. 9 in. long extending from the sub-basement floor to above the first floor. All of the other columns have a uniform length of 22 ft. and a cross-section varying between the limits already mentioned, but terminating in the basement and sub-basement stories with a uniform dimension of 12-in. flange and 14-in. web made with either 4x6 or 6x6-in. flange angles.

All columns have simple cast-iron pedestals 21 in. high seated on solid rock, except adjacent to the next building, where in order to bring them close to the party line the pedestals are seated on grillages of 10-in. I-beams 5 or 6 ft. long, which distribute the pressure longitudinally. The wall columns are enclosed in interior pilasters made by extensions of the brickwork. On the two street fronts two 10-in., 15-lb. fascia channels to support the metal cornice are carried about 2 ft and 3½ ft. beyond the centers of the wall columns by cantilever girders each of which consist of a pair of 10-in., 15-lb. channels back to back with a solid web gusset plate riveted between their inner ends to give connection to the face of the column.

The exterior walls are carried at every story by plate girders made with a 20¾-in. web plate and four 3½x3½-in. flange angles, both webs and angles varying slightly in thickness to correspond with the different surfaces. The lower outside flange angle is made full length, the other three flange angles of each girder are cut to clear the columns and the web plates are field riveted across the column flanges except in four cases where the corner columns have connection angles to receive the girders at right angles to their flanges. In all cases below the thirteenth floor the girder web is made in three sections with the short end pieces projecting from two to four feet above or below the top or bottom flanges of the girder to form gusset-plate knee-braces in the corners of the panels made between the columns and girders. The inclined edges of the knee brace plates are stiffened with pairs of 3x3-in. angles below the tenth floor in two sides of the building and below the third floor in the third side. Those of the fourth side on the 4th Ave. front not being stiffened at all. On the party side of the building the knee braces are placed on the under sides of the girders in the sub-basement, basement and first story. Otherwise they are throughout as above described. Exposed braces are carried across the court at the eighth and thirteenth floors and roof.



Column with Wind Bracing Connections.

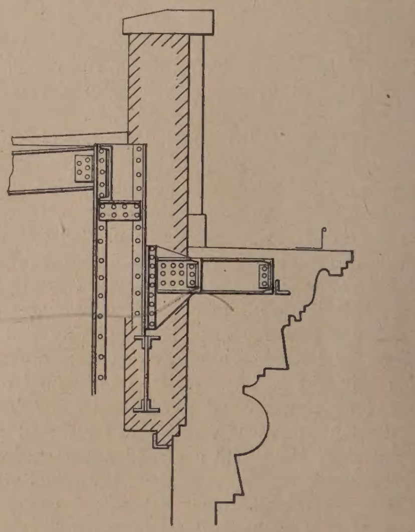
The building contains about 950 tons of structural steel which was fabricated at the Ambridge plant of the American Bridge Co. Mr. S. S. Beman was the architect, and Mr. N. Ronneberg was the structural engineer.

Bitulithic Pavements may be laid in Iowa cities under a decision recently made by the Supreme Court of that State in Saunders v. Iowa City et al., 111 N. W. Rep., 529. The court rules that the bitulithic monopoly cannot be considered odious in the eye of the law. The field for the use of paving materials and methods is limited, the court considered, and if cities may not avail themselves of new discoveries in this line, little encouragement will be given to invention, and we must depend upon the cobblestones of our forefathers. If the material for a pavement selected in a legal way is wholly or partly patented, there cannot be absolutely free competition, and where that is impossible, the court decided, the Legislature never intended that improvements should cease or antiquated methods only be adopted.

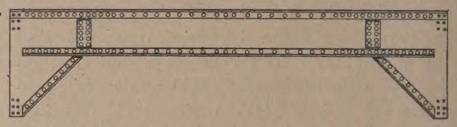
Sampling Coal for Government Buildings.

The methods adopted by the Treasury Department in purchasing coal for use in federal buildings were described in the Engineering Record April 6 and formed the general subject of three papers read at the recent convention of the American Society for Testing Materials, as reported in the Current News Supplement of this journal on June 29. An important lesson of the experience gained to date in purchasing coal on the thermal unit and ash basis is the necessity of taking great care in sampling coal, so as to obtain a fair average. This was particularly shown in the paper presented to the convention by Messrs. J. A. Holmes and D. T. Randall, of the U. S. Geological Survey, based on three years' experience in comparing samples obtained in the mine and from cars. Two methods of sampling have been tried. In one the sample is taken and impurities discarded in accordance with instructions to miners for separating foreign matter from the coal. This method, when checked by samples taken from coal shipped in cars under ordinary working conditions, shows that mine samples are usually considerably better than the actual delivery, due to the failure of the miner to fully carry out instructions. This difference may be indicated by comparison of the ash content of the coal in the two cases. The average results show for run-of-mine coal 30 per cent. more ash in the coal delivered than in the mine sample. The other method of mine sampling follows as nearly as possible the actual methods which the miners follow, regardless of what their instructions may be. By this method samples may be secured by an experienced inspector which correspond very closely with the car deliveries, but considerable time is required for observing the work of the miners in different parts of the mine, and the judgment of the inspector is depended upon to secure the result.

In both methods the following precautions are taken by the inspector to secure a correct sample. A vertical cut is made over the face of the coal and the cuttings are caught upon a waterproof blanket which is spread upon the floor of the mine. Impurities are rejected, in accordance either with the instructions or with the usual miners' practice, and after being crushed to ½-in.



Support of Cornice and Parapet, Berger Building.



Wind Brace, Berger Building.

pieces or smaller, the coal is thoroughly mixed. It is then quartered down and the resulting sample is placed in a metal can holding about one quart and sealed air tight. All of this work is done in the mine where the sample is taken and as rapidly as possible to avoid loss of moisture. A full description of these methods and results may be found in the Geological Survey Bulletin No. 290.

Samples as usually furnished from mines are not to be depended upon as representing the coal which will be delivered. This difference is mainly due to failure of the miners to obey instructions regarding the rejection of impurities, to differences in the quality of the coal in different parts of the mine, and to the fact that different beds of coal are often mined at the same time and the output mixed. Lack of cars in mining and in preparation of coal for the market explains in a great measure the variation in the amount of ash in the coal delivered from the same mine at different times. In sections of the country where coal is washed variation in the quality may be considerable, due to the carelessness of the attendant in charge of the washery. The tendency with persons inexperienced in sampling is to select a sample much better than the average product. In many cases samples are taken by selecting a nice looking lump, breaking it down and shipping it in a cloth sack, thus allowing the moisture to evaporate. Such a sample, of course, represents the best coal in the mine and (unintentionally, in most cases) establishes a much higher value than can be commercially delivered.

Complete Steel Framework, Berger Building.

The mine sample, if properly taken, does, however, establish the general character of the coal and indicates what may be expected under favorable circumstances.

During the past winter samples of coal from several of the Government buildings in Washington were secured by members of the Fuel-Testing Division of the Geological Survey and the analyses were made by the Chemical Laboratory conducted by this division under direction of Prof. N. W. Lord, of Ohio University. Samples were usually taken from the coal as it was being unloaded from the cars or from wagons. In the case of car deliveries it has been found that it is necessary to take small quantities from many parts of the car as it is being unloaded, in order to obtain a fair sample, for the reasons that the coal is often brought to the car from different parts of the mine, and in transit the heavier portions of the coal tend to settle to the bottom. The analysis of samples from the top and bottom of cars often show very considerable differences in the percentages of ash. In case coal is delivered to the buildings in wagons and stored in bins, it is preferred to obtain the sample by taking a small quantity from each load or at regular intervals as the wagons are being dumped into the bins. In cases of small deliveries of anthracite coal it has been found satisfactory to take samples from a number of points over the surface of the coal when it has been impossible to channel through the bin, which is preferred when practicable.

These samples vary from 100 to 500 lb., according to the amount of coal delivered. The coal is collected on shovels in such a manner as to represent the delivery as closely as possible, and is placed in closed cans, each holding about 60 lb., which are locked when filled. These samples are then sent to the laboratory crushing room in the Geological Survey Building and crushed in a small rotary crusher to ⅜-in. pieces or smaller. The crushed coal is automatically divided into quarters by passing through a special sampling tube designed by the chemical division. The resulting sample is further reduced by quartering until a quart sample is secured. Precaution is taken throughout the work to prevent loss of moisture.

Waste Heat Boilers for Copper Smelting Furnaces.

An interesting smoke flue boiler installation has recently been made at the smelting plant of the Colusa-Parrot Mining & Smelting Co., at Butte, Mont., for the utilization of waste heat from the copper smelting furnaces. The installation follows in general lines the practice that has been customary in steel mills for the utilization of heat from reverberatory and similar furnaces, but in plants where chemical processes are involved, the difficulties attending the use of the smoke flue boilers have prevented its more general adoption. While in furnaces for heating metals for forging and working, the waste gases of combustion carry little soot and dust, where chemical processes like smelting and ore roasting are involved, such large amounts of dust and friable matter are carried over from the ore that considerable difficulty is usually experienced in the operation of the boiler, owing to the rapid accumulation of this flue dust on the boiler tubes, with consequent reduction of their heat-absorbing capacity. Especially in the case of copper smelting furnaces is this difficulty encountered, so that only boilers whose heating surfaces may be quickly and effectively cleaned while in operation, are adaptable, and those of the water-tube type with inclined tubes have been found in practice to be the more desirable. Moreover, this dust and friable matter carries a considerable quantity of metal, so that its recovery by deposition in any manner is both desirable and profitable.

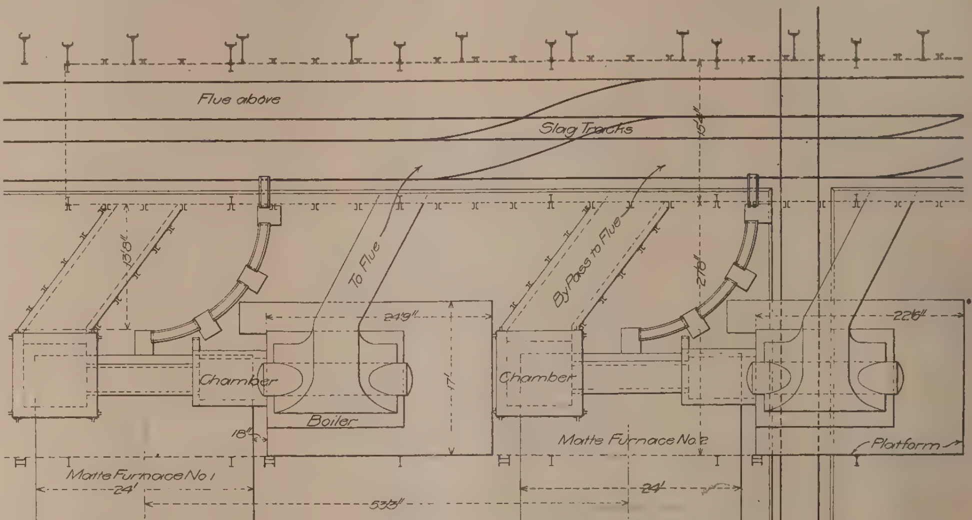
There are three matte furnaces at the Colusa-Parrot smelters, each having chimney flues 32 x 45 in. in cross section, which were formerly connected directly into tall stacks. The furnaces are all of the reverberatory type, with 5x10-ft. grates, and are fired with coal, the waste gases formerly passing to the stacks at temperatures ranging from 1,500° to 2,000°. In the application of the waste-heat boilers to the furnaces, it was the desire so to arrange the flue gas connections that a by-pass might be secured for use in case it might be necessary to take the boilers out of service, and accordingly provisions were made for the boilers at the front corners of the furnace settings, on the opposite sides from the by-passes. The matte furnaces are located 51 ft. apart between centers, which allowed fully 24 ft. between the settings; at the front and above these spaces at one end substantial platforms 17 x 24 ft. in size were erected upon which the boilers are supported. The platforms are elevated about 7 ft. above the main floor level in order to bring the heating surfaces of the boilers at a convenient level above the flue gas connections. The platforms consist of four latticed posts under the corners of the boilers, upon which are carried 12-in. I-beams transversely, that support six 10-in. I-beams, 24 ft. in length, three under either side of each boiler. The platform is extended about 3½ ft. on all sides of the boiler and is fitted with a railing to form a working gallery.

The details of arrangement of the flue connection to the boiler are shown in the accompanying drawing. From the furnace a flue outlet, 32 x 45 in. in section, is carried up directly to the combustion chamber of the boiler; directly above this is located the boiler. The course of the waste gases is from the furnace through the flue to the combustion chamber under the boiler and thence upward through the heating surface of the boiler and discharging through a special breeching which extends to a flue leading to a settling chamber and stack. The settling chamber is a brick duct, about 50 ft. wide x 19 ft. high inside and several hundred feet in length. The chimney is a circular brick stack, 352½ ft. in height, which is substantially built on a heavy slag foundation, the reinforcement of the latter being of steel rods and bars, around which the slag was poured while in molten state.

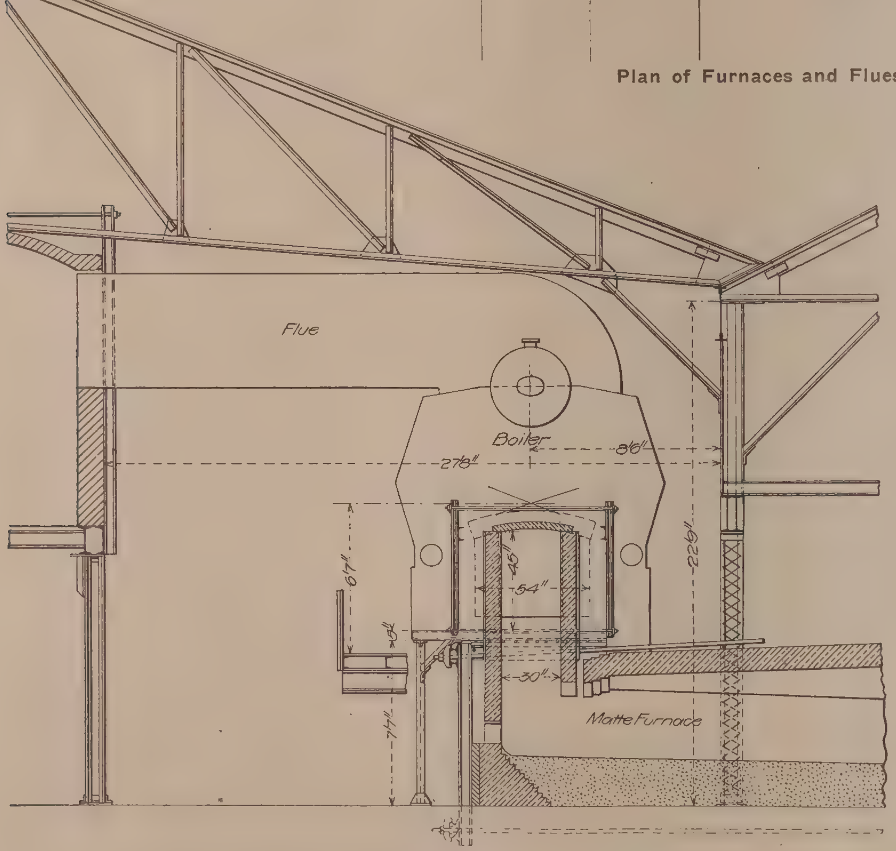
The boiler used with each Matte furnace is a 515-h.-p. unit of the Worthington type, built by the New York Safety Steam Power Co., which has a specially designed casing rendering it well adapted to this class of service. It embraces the usual Worthington construction, consisting of a centrally located horizontal steam drum with inclined banks of tubes, the steam drum being 42 in. in diameter by 20 ft. long. There are 61 sections of water tubes, each with eight full-length tubes and one shorter tube connecting with the lower side of the drum, making 549 tubes in all. The tubes are 3 in. in diameter and 10 ft. in length, the total heating surface presented in each boiler being 4,635 sq. ft. Apart from its size the boiler presents no unusual features with the exception of the casing, which is of special design to permit cleaning while in service, not only for the purpose of keeping the heating surface free from dust and matter deposited from the furnace, but also to enable this material to be reclaimed for return to the smelter.

The entire outer casing of the boiler, which is of the usual sheet metal construction, is formed of hinged doors, of which there are two on each end and six on either side, to facilitate the cleaning of the heating surfaces. The by-pass flues permit any boiler unit to be cut out of service at any time desired in order to enable this cleaning to be done, but the spaces between the tubes may be kept free from accumulations through slotted openings in the lower doors at both front and back, through which bars may be inserted. The slots are 2 x 10 in. in size, cut through the doors in line with the openings between the headers of the boiler, and are covered by small flap doors, hinged and held by buttons on the main doors. Each flap door covers only five of these openings, so that it will be seen that by opening but one of these doors at a time, the boiler may be cleaned while it is in operation without sensibly interfering with the draft. The operation of the cleaning bar through the slot openings keeps the boiler free from any deposit between the tubes vertically, while the side doors permit the introduction of a nozzle to blow the dust from the tubes horizontally.

In operation the waste heat boiler units have been very successful, it having been found that, with this arrangement of flue connections, there is no diminution in the capacity or economy of the matte furnaces, and sufficient steam is produced for the operation of the entire plant, without the use of the boilers that were formerly operated for steam production. While the waste gases formerly went to the stack at temperatures of from 1,500° to 2,000° Fahr. they are now discharged at a temperature of about 500°; in order to provide ample draft, a tall single stack was erected to replace the independent stacks that formerly served each of the furnaces separately. The boiler settings are also found effective as settling chambers, considerable amounts of the metal-bearing material carried over from the furnaces being reclaimed from the combustion chambers under the boilers, for return to the furnace or smelter.



Plan of Furnaces and Flues at the Colusa-Parrot Smelters.



Connection between Boiler and Furnace Flue.

Traction in the Detroit River Tunnel.

Traction in the Detroit River Tunnel now under construction will be conducted at first with six 100-ton direct-current locomotives of the swivel truck type, with geared motors. Each locomotive is designed to haul a 900-ton train up a 2 per cent. grade at a speed of 10 miles per hour. Current for operating the motors will be taken from a third rail by contact shoes. Power for the operation will be purchased from the Detroit Edison Co., and will be delivered at a sub-station at a potential of 4,400 volts and a frequency of 60 cycles. At the sub-station two 1,000-kw. synchronous motor-generator sets will be installed for supplying direct current to the third rail. The yards and approaches to the tunnel will be lighted by arc lamps while the tunnel itself will be lighted by incandescent lamps. Alternating currents from the main power supply at a frequency of 60 cycles will be used on the lighting circuits. For draining the tunnel there will be five sumps, each fitted with a pair of centrifugal pumps driven by induction motors. The sub-station will be provided with a regulating storage battery to carry the fluctuations of the load. The electrical equipment of the tunnel will be furnished by the General Electric Co.

A 22-Degree Curve on the Canadian Pacific Ry., between Golden and Field, B. C., known as Kicking Horse Pass curve, has recently been replaced by a new cut-off with maximum curvature of 8 deg., which involves a tunnel 693 ft. long. The old curve was on a detour line around a bend in the Kicking Horse River, which had been made necessary by the caving in of the old "Mud Tunnel" 20 years ago; the detour was 2,880 ft. long, 755 ft. of which was curved to a radius of 262 ft., so that no elevation of the outer rail was possible on account of "cornering" of passenger coaches. The cut-off shortens the line 1,192 ft.

The New Settling Basins and Other Improvements to the St. Louis, Mo., Water-Supply System.

The water supply for the city of St. Louis is drawn from the Mississippi River at the Chain of Rocks, 10 miles above the business section of the city. At this point a tunnel extends under the river to an intake tower in the channel of the latter, and is connected at the shore end to low-service pumps in a station building 500 ft. back from the edge of the river bank. These pumps deliver at present to a series of six large settling basins immediately downstream from the pumping station, the six basins having a combined capacity of 180,000,000 gal. From these basins the settled water flows by gravity through a horseshoe-shaped brick and masonry conduit, 11 ft. wide at the springing line of the arch and 9 ft. high, to two high-service pumping stations, known as the Baden Station and the Bissell's Point Station, which are approximately 4 and 7 miles, respectively, down the river from the low-service pumping station at the intake.

General View of New Basins During Construction.

In order that the facilities for supplying and distributing water to the city should keep pace with the exceptionally rapid growth of the latter, additions to and extensions of the supply and distribution systems had become an immediate necessity. Two new settling basins at the Chain of Rocks, a 7-ft. steel pipe flow line paralleling the existing conduit from these reservoirs to the Baden high-service pumping station, and a storage reservoir at this station are the most important features of the additions and extensions to the supply system that have been undertaken. A large building containing storage space for the coagulants used in the clarification process employed in the settling basins, the machinery necessary in mixing these coagulants and applying them to the raw water, and a new high-service pumping station are among other improvements to that system that are to be put under construction soon.

The six existing settling basins are each 400 x 670 ft. in plan and are placed side by side, a masonry division wall separating the adjacent basins. The side walls of these basins are of stone masonry and their bottoms are concrete, embankments being placed around the walls. Under normal conditions of operation the raw water enters the upstream basin through four 3 x 3-ft. openings controlled by sluice gates. It flows from this basin over the dividing walls between the successive basins and is drawn into the brick and masonry conduit from the downstream one of the six basins, known as Basin No. 6. Supply and effluent connections are made, however, so the water may be admitted to or drawn from the various basins in practically any combination of the latter, in order to provide for cleaning and for emergencies of operation. The bottom of each of these basins is sloped from both sides to a trench along the longitudinal center line, to facilitate the removal of the sediment that is deposited from the raw river water. A 24-in. sewer outlet controlled by a gate valve in a gate house in the embankment extends from the end of this trench to the river, about 500 ft. distant.

The two new basins are being built between the existing basins and the river, covering together an area 400 ft. wide by 1,660 ft. long. They have reinforced concrete side and end walls backed by earth embankments, their bottoms being lined with 9 in. of concrete. The two basins are separated by a division wall, consisting of two reinforced concrete walls spaced apart and filled between with puddle, the total thickness of the walls and puddle being 9.5 ft. The bottom of each basin is sloped to two transverse trenches under which is laid a 30-in. sewer leading to the river. The basins are each 400 x 800 ft. in plan and have an average depth of about 21 ft., their combined capacity being 75,000,000 gal. The total capacity of the eight basins will be 255,000,000 gal., which is increased to 394,000,000 gal. when the new basin at the Baden station, four basins at Bissels Point Station and a distributing reservoir on Compton Hill in the city are considered. As the average daily consumption is approximately 72,000,000 gal., five and one-half days' storage capacity is provided.

A by-pass consisting of a double 4x7-ft. reinforced concrete box conduit has been laid between the six existing and the two new basins in order that one or more of the eight basins may be cut out of service if desired; the two new basins are each connected with this conduit from which they may be supplied separately. The downstream one of the new basins, known as Basin No. 7, is connected with the downstream basin of the six existing ones, called Basin No. 6, so that water may be diverted from the former into the latter. The new basins are interconnected and have independent connections with the brick and masonry flow-line conduit leading to the high service pumping stations. Basin No. 7 also has a connection with a gate chamber from which the new 7-ft. steel flow line will be supplied.

The usual method of operation when the new basins are placed in service will be to pass the water through the existing basins in the normal manner, then through Basin No. 7, into Basin No. 8, and thence into the brick and masonry flow-line conduit, from which it may be diverted into the 7-ft. steel flow line at the south end of the system of basins. The various connections that have been provided, however, provide for a number of different combinations of the basins, making the sequence of operations entirely flexible. The connections between the various basins and between the latter and the by-pass and conduits are all controlled by sluice gates and valves. These gates and valves are placed in concrete gate chambers, built with the walls of the basins as their outer sides. The walls of the chambers are carried up to the tops of the basin walls and are to be covered with removable cast-iron floor plates.

A gate chamber at the inner downstream corner of Basin No. 7 is called Chamber No. 1. It contains two compartments, one 10 ft. square and the other 10x12 ft. in plan, which are separated by a 4-ft. concrete wall. The connection between Basin No. 6 and Basin No. 7 is a reinforced concrete conduit, having a 4 x 8-ft. rectangular cross-section. This conduit terminates in the larger compartment of chamber No. 1, 10.25 ft. above the bottom of the latter, in which it is controlled by a 4x8-ft. sluice gate. The outlet from this compartment is a two 4x4-ft opening in the opposite side of it, leading into the basin. A 6x7-ft. opening in one side of the other compartment of this chamber connects the latter with the basin, the opening being controlled by a sluice gate. The outlet from this chamber is a 7-ft. steel pipe which connects through the terminal conduit chamber nearby with the new 7-ft. flow line.

A connection from Basin No. 7 to the by-pass is made about midway in the side of that basin, terminating in a 10x15-ft. gate chamber known as Chamber No. 2. The connection with the by-pass is a double reinforced-concrete box conduit, each part of which is 5 ft. square in cross-section. The outlet from the chamber is a 6x7-ft. opening fitted with a sluice gate of that size.

The third one of the gate chambers, known as Chamber No. 3, is at the inner end of the dividing wall between Basins No. 7 and No. 8. This chamber has two compartments, each 10x13.5 ft. in plan, which are connected by an arched opening in the wall between them. A connection with the by-pass, of the same type and size as the one in Chamber No. 2, ends in one of these compartments and is controlled by two 5x5-ft. sluice gates. A 7-ft. steel pipe extends from the other compartment to the brick and masonry flow-line conduit, and is controlled by a 7-ft. circular sluice gate. A 6x7-ft. opening in one chamber connects the latter with one basin and the second basin is connected with the other compartment by an opening of the same size. With this arrangement the two basins may be connected, either or both basins may be supplied from the by-pass and either or both basins may discharge into the brick and masonry flow-line conduit through this conduit.

A fourth gate chamber, known as Chamber No. 4 and similar to Chamber No. 1, is placed at the inner upstream corner of Basin No. 8. This chamber has two independent compartments, one 10 x 10 ft. and the other 10 x 15 ft. in plan. A 7-ft. steel pipe line from the receiving chamber which supplies raw water to Basin No. 1 leads into the larger compartment, which also has a connection with the by-pass, of the same size and type of those already mentioned, and has a 6x7-ft. opening into the basin. The two supply connections are each controlled by gate valves. The smaller compartment has a 6x7-ft. opening connecting it with the basin and a 7-ft. steel pipe connection with the brick and masonry conduit, the opening into the basin from it being controlled by a sluice gate.

Three 30-in. cast-iron pipe lines are laid across each new basin under the floor, and at one side of the trenches in the latter. They replace the 24-in. vitrified pipe sewers which formerly served the existing basins. The trenches in the floors of the new basins are each connected with them at three places through 24-in. pipes having 24-in. non-rising steam valves placed in concrete chambers built in the trench. One of these connections is at the river side of the basins and the other two are at equal distances apart across the latter. A steel tower carrying a working platform above high-water level in the basin will be placed over each of the valve chambers not against the side wall in order that these valves may be operated from the stands when the basins are filled.

The site of the two new basins is a strip of the river bank from 725 to 825 ft. wide between the existing basins and the river. The greater part of the natural surface of this site is 2 to 5 ft. above high water. The basins are being built partially in cut and partially with embankments against the back faces of the concrete walls which form their sides. The greater part of the walls, however, is above the level of the natural surface.

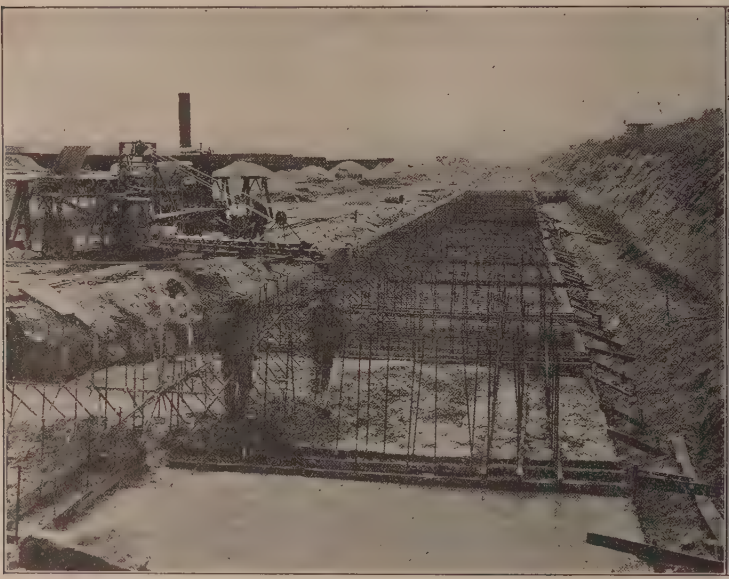
The bottoms of the basins are being built almost entirely in excavation, a mixture of river silt and sand being uncovered over a large portion of their sites. A layer of puddle, having a minimum thickness of 18 in., is placed over the bottom of the excavation before the concrete bottom is placed. The latter has a minimum thickness of 9 in. and is laid in 8x8-ft. blocks, the surface being troweled to a smooth finish. The blocks are separated to their full depth by ½-in. joints, which are filled with an asphalt cement filler. This filler is required to remain pliable at zero Fahr., and to have a melting point of not less than 210° Fahr. In addition to containing at least 92 per cent. pure bitumen it must be free from any coal tar products.

The footings of the reinforced concrete side walls of the basins are 25 ft. wide and 18 in. thick, the walls rising to a height of 22.5 to 24 ft. above them, depending on the elevation of the bottom of the basin at the point in question. The base of the wall proper is 2.5 ft. thick, the footing being stepped down to that width. The front face of the wall is vertical, but the rear face is battered slightly, the thickness at the top just below the coping being 18 in. The wall is designed as a buttressed retaining wall capable of resisting the forward overturning moment brought about by the fill against its rear face, as well as a backward overturning moment caused by the pressure of the water on its front face. The buttresses against the back face are placed 16 ft. apart on centers and are built continuously with the wall and footing, the latter extending at its full width for the full length of the wall. The walls are entirely without expansion joints, the reinforcement being designed to provide against cracks due to temperature changes. A continuous wall 1,600 ft. long is thus made on each side and one 400 ft. long at each end of the two basins. The wall on the river side has nearly all stood through three changes of seasons during the construction without having shown any cracks due to temperature.

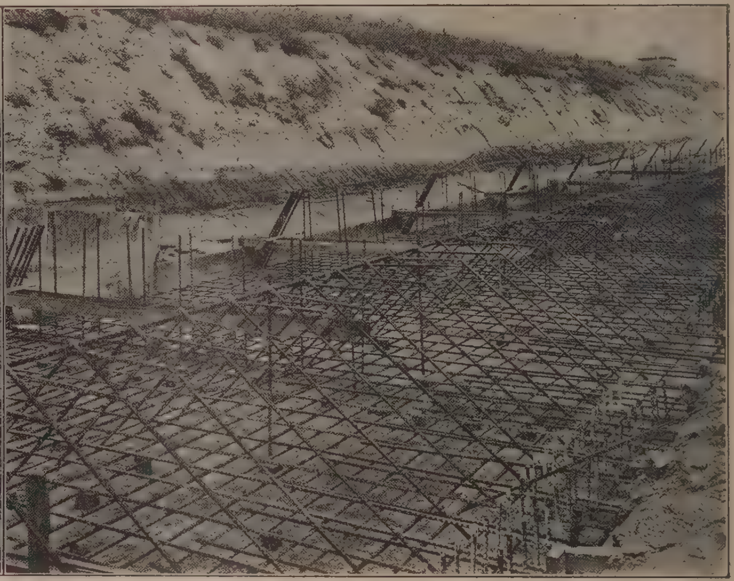
The soil of the site has sufficient sustaining capacity to carry the walls on the regular footings except at the outlets of the three sewers in each basin leading from the latter to the river. A heavy concrete wing wall is placed on both sides of these outlets and the excavation for the trench leading up to the outlets had to be carried considerably below the level of the remainder of the basin floor, with the result that extremely poor soil was encountered. In order to insure the stability of the walls on the poor soil at these outlets, a section of the wall footing about 64 ft. long is carried by seventy Raymond concrete piles at each outlet. The piles are placed in five rows of fourteen each, the rows being 5 ft. apart on centers, and the piles in the rows from 4 ft. 3 in. to 5 ft. 4 in. apart on centers. The piles are each 6 in. in diameter at the point, 20 in. in diameter at the top and 20 ft. long. They were built by sinking two concentric steel shells together with an ordinary land pile driver having a 2,000-lb. hammer falling 5 ft.; then pulling the inner shell, which is collapsible and much the heavier, and filling the outer one with concrete. Each pile was reinforced with six ¾-in. corrugated bars. This method is controlled by the Raymond Concrete Pile Co. of Chicago, and has been described at length in this journal. The maximum load on the footing where these piles are used is about 2,800 lb. per square foot, the maximum load on the piles being 35 tons to a pile.

The details of the reinforcement of the footings, walls and buttresses are shown in one of the accompanying illustrations. Johnson corrugated bars are used in all cases where the concrete is reinforced in connection with the work on the basins, ¾-in. rods being employed chiefly in the footings, walls and buttresses. The footing is a horizontal beam 18 in. thick, which is designed to resist upward stresses, as well as the load brought on it. The walls and buttresses are thoroughly tied into the footing, and the buttresses into the wall by reinforcement bars. The wall proper is designed as a continuous beam placed on edge, with the buttresses as points of support. The principal reinforcement is therefore laid horizontally and extends longitudinally near the faces of the wall. Shorter horizontal bars are also placed at the buttresses, as shown, to provide for the stresses set up at those points. Vertical bars are placed in the same plane as the horizontal bars in order to tie the wall together and to cause it to act as a uniform beam. The coping on the top of the wall is 12 in. thick and 4 ft. wide, and is reinforced sufficiently to carry its overhanging portion between the buttresses, and to prevent cracks.

Two classes of concrete are used in the construction of the basins and the various structures connected with them. One of these is specified to be made in the proportions of one part cement, three parts sand and six parts broken stone, by measurement, a barrel of cement being considered as 3 cu. ft., which actually produces a 1:2¼:4½ mixture, as proportions are ordinarily stated. The proportions of the other class, as specified, are one part cement, four parts sand and eight parts broken stone, or one part cement to nine parts of a mixture of sand and gravel, also by measurement, the barrel of cement again being considered 3 cu. ft. The 1:4:8 or 1:9 concrete is used for

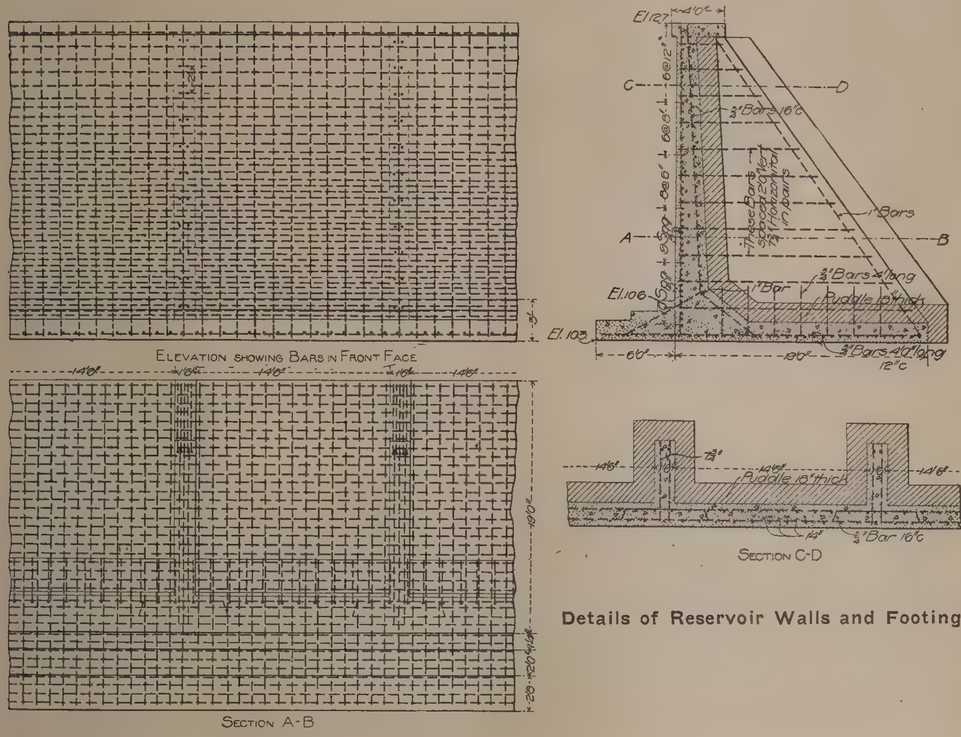


Concrete Mixing Plant Used on Footings of Walls.

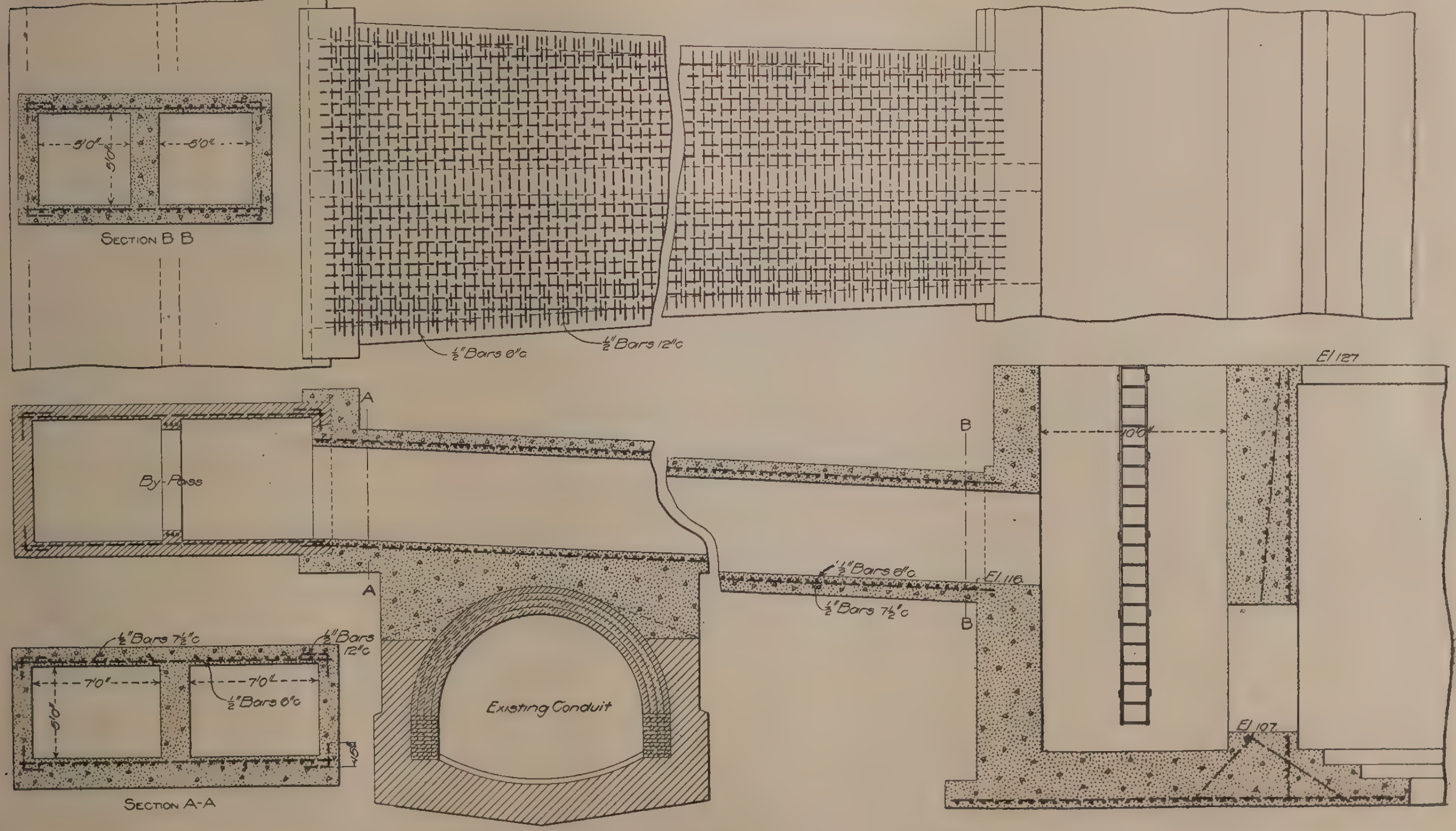


Reinforcement Bars in Place for Wall Footings.

lining the floors of the basins; in all other concrete construction the 1:3:6 mixture is employed. Red Ring Portland cement is used in all of the concrete, over 50,000 bbl. being required. This cement is subjected to tests approximately the same as the standard tests recommended by the American Society for Testing Materials. Clean, sharp river-channel sand, free from loam and dirt is required. Sound, clean limestone, crushed and screened, is used, the pieces ranging in size from those that would be retained on a ¼-in. screen to those which would pass a screen with 1½-in. meshes. The gravel used is dredged from the Meramec River, and is washed and screened before being delivered.



Details of Reservoir Walls and Footings.



Details of Typical Reinforced Concrete Conduit.

Construction of the Basins.—The Water Department of St. Louis operates an electric railway, 7 miles long, from the Bissells Point high-service pumping stations in the city to the low-service pumping station at the Chain of Rocks. This railroad connects with steam railroads in the city, and over it all of the supplies for the work are delivered by a steam locomotive owned by the city. The main railroad track traversed longitudinally the site of the two new basins and practically the first construction work done on the latter was to relocate this track on the river side of the site. Two side tracks from this main track were then laid the full length of the site from the upstream end of the latter, one adjacent to each longitudinal wall of the basins. The materials for the work can thus be delivered directly in cars to within 75 ft. of the point where they are to be used.

The first work that was done on the basins themselves was to excavate the trenches for the footings of the walls on the river side and the downstream end. These footings were then laid the length of the walls, which were built later, reinforcing bars and keyed recesses serving to tie the new concrete to the old, although the latter was also well cleaned before any fresh concrete was laid on it. Meanwhile, work was started on the footings for the walls on the other side and end of the basins, the footings for these walls being completed in time so the work on the walls resting on them could be carried forward without interruption when the first walls were finished.

As the top of the footings are in all cases at or below the natural ground level of the site, the concrete did not have to be elevated to them. On the other hand, since the footings contain a comparatively small amount of concrete per linear foot of wall a stationary central mixing plant from which the concrete could be delivered in cars, or by other means, to the position it was to occupy was impracticable. The requirements governing the method of constructing the wall proper, as will be described later, were also against the use of a central mixing plant. Two portable self-propelling concrete mixing and conveying outfits, built by the Drake Standard Machine Works, of Chicago, were accordingly designed for the work of the footings.

Each of these outfits consists of a standard Drake continuous mixer with its 20-h.-p. engine and boiler mounted on a four-wheel truck, which is fitted with a traction gear driven by the engine. A boom, 25 ft. long, carrying a 20-in. traveling belt conveyor is supported from the front end of this truck in such a position that the concrete is discharged on the belt directly from the mixer, and as the boom can be swung through an arc of 90 deg., concrete is delivered into the footings from the mixer by the conveyor. The sand, gravel and cement for the concrete were delivered in barrows from storage piles and cars along the branch railroad tracks extending the length of the site, to the machines and elevated by super-hoppers into the mixer troughs. The mixing outfits were moved on 4x16-in. plank runways laid on the ground along the walls. Each of these mixing outfits could place on an average about 100 cu. yd. per 10-hr. day, with 25 men, allowing for delays, time of moving, and so forth.

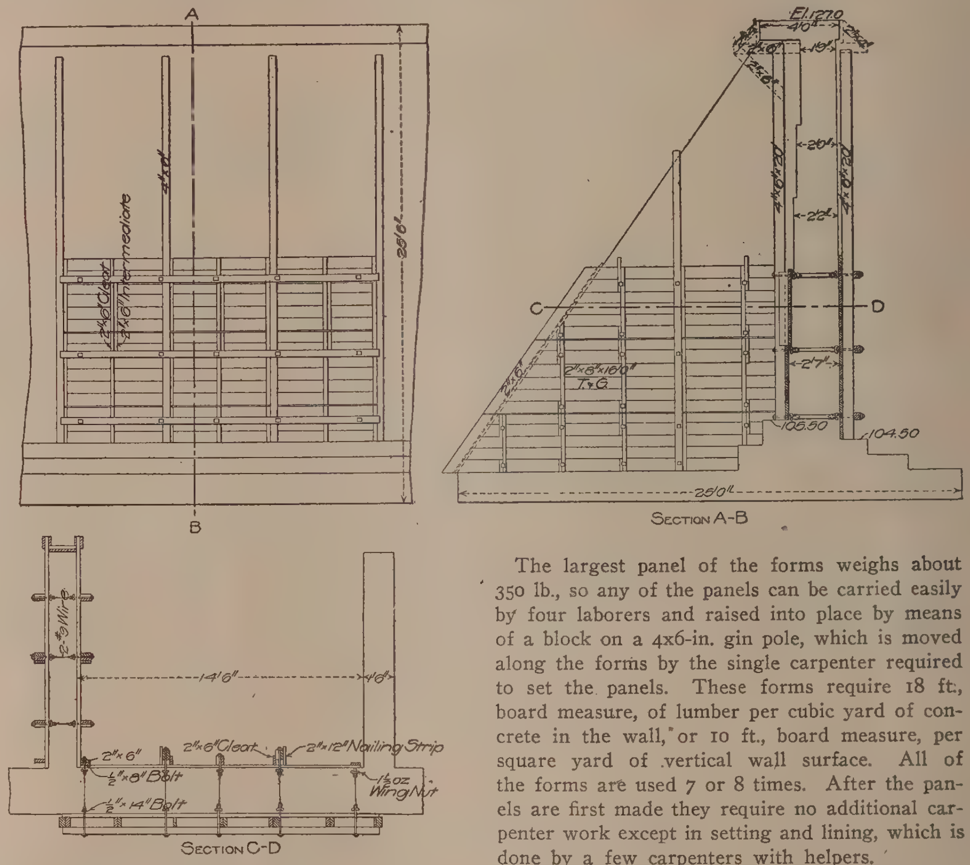
The type of the mixing outfit employed on the walls was governed entirely by the design of the walls, the manner in which they were required to be built, and the design of the forms. At the same time the design of the walls and buttress forms was controlled materially by the following considerations: The concrete was required to be placed in layers not exceeding 4 ft. in depth; provision had to be made in building the 4,920 linear feet of walls to permit the work to be stopped with keyed bulkheads, at the end of each day's work, in a form so narrow and so filled with reinforcing bars that a man could not work within it; and longitudinal reinforcing bars had to be placed after each layer of concrete had been laid.

The solid concrete wall with counterforts, forming a structure capable of resisting pressure from either face suggested the possibility of designing a hollow self-contained and self-sustaining timber wall, without bracing, for the forms. A form of this type was accordingly adopted, and is designed so it can be taken down in sections and erected again with a minimum amount of labor. In fact, in detailing the forms attention was devoted to minimizing the amount of lumber necessary by using the latter repeatedly, to the construction of sections of the forms of such size and weight that they could be placed and removed rapidly, and to simple methods of fastening and to the reduction of skilled union carpenter labor at 60 cents an hour as compared with unskilled helpers at 22½ cents per hour.

The lagging for these forms is made of 2x8-in. tongue and groove planks, faced on one side. This lagging is converted into panels, 3 ft. 2 in. to 4 ft. in height when placed vertically in position, and of different lengths, depending on the portions of the wall for which they are made. The panels on the front face of the wall are all uniformly 16 ft. long, extending from the center of one wall buttress to the center of the next; those for the back face of the wall are 14 ft. 2 in. in length extending from the forms for one buttress to those for the next; the panels of lagging for the buttresses have one beveled end and are gradually reduced in length from the bottom to the top of the buttresses to correspond with the slope on the back of the same. The planks forming each panel are cleated to 2x6-in. uprights, placed 30 in. apart on centers to prevent warping. The bottom panel of both the front and rear faces of the wall form rests on offsets in the footing of the wall. The remaining panels of the front face of the form are set on the lower panels later, but the succeeding panels of the rear face form each rest on a 2-in. offset in the back face of the wall. These offsets are spaced so their inner corners fall outside a line drawn to the batter proposed for the back face of the walls in the original design. The amount of concrete in the walls is thus increased only about 100 cu. yd. on all the walls by the change, while the saving attained in building the forms was very great. The panels of the front face of the forms are held in position by vertical 4x6-in. timbers, 20 ft. long, which are spaced four to a 16-ft. front panel. The rear face panels have two of these 4x6-in. uprights at the quarter points, their ends resting against the forms for the buttresses. The alignment of the front face forms is preserved by a horizontal 4x4-in. timber to each 4-ft. panel, these horizontal pieces being placed against and bolted to the 4x6-in. uprights.

The two faces of the forms are tied together by wires which are attached in such manner by means of bolts and wing nuts, that, as compared with the usual method of binding the wires around the uprights of the forms and cutting them when the latter are removed, only half the number of holes need be bored, the labor of wiring is diminished and wire is saved. At the same time, by turning up the bolts an even strain can be brought on all the wires holding a panel thus preventing the forms being broken out when the concrete is poured. The wires are held by ½-in. bolts, with ⅛x2¼-in. wrought-iron washers and ½-in. wing nuts. The bolts are placed through the uprights of the forms, the nuts being inside the latter. The bolts are placed in pairs, one bolt in the front face and the other in the rear, two No. 9 wires holding together the wing nuts on each pair of bolts. These wires are prepared in advance for the various lengths required at different heights of the wall. They have loops on their ends to fit over the wing nuts, these loops being made by holding the loose end of the wire in a vise and twisting the other end with a small rod so as to crimp both strands at the loop and prevent slipping. As shown in the accompanying sketch of the forms, intermediate 2x6-in. cleats are slipped along the cleats on the panels of the front face of the forms to reach the 4x4-in. longitudinal below the level to which the concrete has already been carried. These intermediate cleats reduce the number of wires and permit the upper wires of each panel to be raised so they can be reached from the top of the form, which method is required by the narrowness of the forms. When the forms are to be removed the bolts are screwed out of the wing nuts and the small holes resulting in the face of the concrete are filled with mortar. The walls are not given a mortar face, the only finishing done being to spade the concrete against the forms, but a good smooth surface is secured in this manner.

The walls and buttresses are carried up about 4 ft. at a time over a section 20 to 30 panels of the forms in length, depending on the working conditions. The 4x6-in. uprights of the forms are first set true to line and then the lowest panels of both faces of the forms are placed over the length of the wall in which concrete is to be laid in a continuous section. After the concrete has been filled in to the top of this lower panel for this length of wall, the next panels of both faces are placed over this length and a second longitudinal layer of the wall is built. The forms are thus erected and the walls built continuously in horizontal sections. These sections are selected of such length that work on the forms can be in progress on one end of this horizontal section while concrete is being placed at the other end of the section without interference.



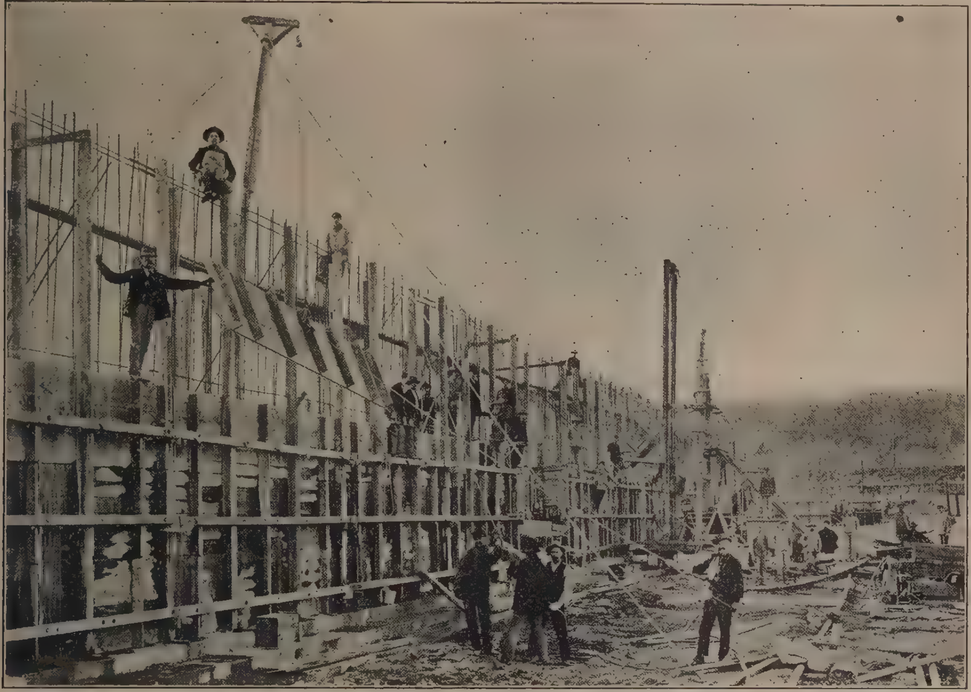
Forms for Building Reservoir Walls.

The largest panel of the forms weighs about 350 lb., so any of the panels can be carried easily by four laborers and raised into place by means of a block on a 4x6-in. gin pole, which is moved along the forms by the single carpenter required to set the panels. These forms require 18 ft., board measure, of lumber per cubic yard of concrete in the wall, or 10 ft., board measure, per square yard of vertical wall surface. All of the forms are used 7 or 8 times. After the panels are first made they require no additional carpenter work except in setting and lining, which is done by a few carpenters with helpers.

A portable concrete mixing and elevating outfit entirely different from those employed in building the footings is used in constructing the walls. This outfit consists of a 11 cu. ft. improved Chicago cubical mixer mounted, with a 20-h.p. electric motor which drives it on a platform carried by a truck having four flat-rim castor wheels running along planks laid on the bottom of the basin. This mixer is equipped with an automatic charging hopper, which is loaded, about 2 ft. above the level of the bottom of the basin, from wheelbarrows and holds one batch of materials for the mixer. The concrete is discharged from the mixer into a specially-arranged automatically-dumped hoisting bucket operating in a pair of vertical leads at the front of the platform on which the outfit is mounted. A chute, also operating in the leads carrying the hoisting bucket is set at the height at which concrete work is in progress, the concrete being dumped from the hoisting bucket through this chute into the forms. The machine is moved along the wall by a rope in a block and fall attached to an anchor at one end, and at the other to a winch head on the hoisting drum driven by the mixer motor.

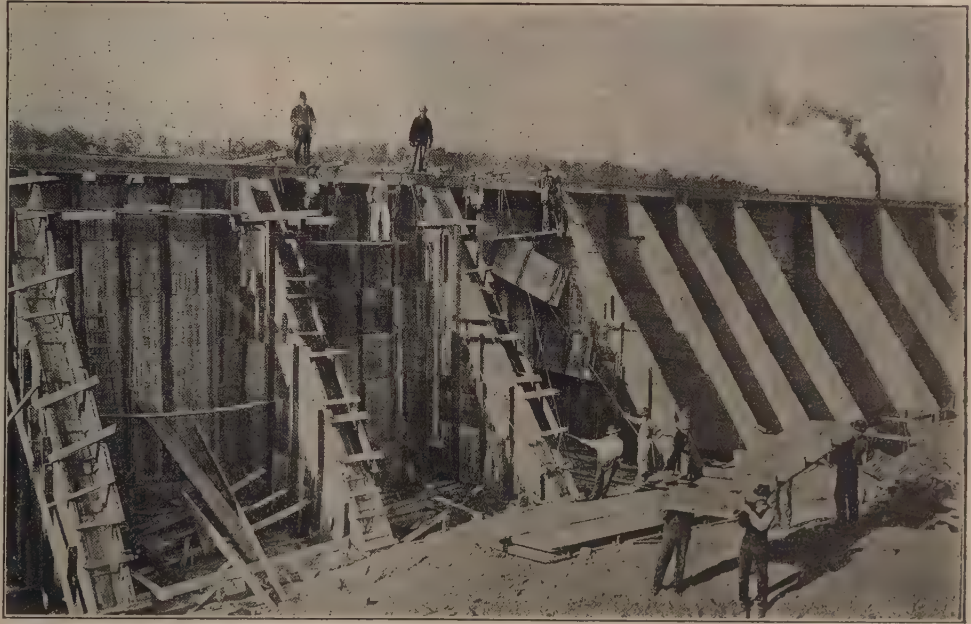
As this outfit can be moved readily, and as concrete can be placed by it at any height of the wall, it is particularly adapted to building the wall in the horizontal sections as required. Under these conditions an outfit can place on an average 80 cu. yd. of concrete in the wall and buttresses in a 10-hr. day.

The 230,000 cu. yd. of earth required to be excavated from the bottom of the basins was handled with New Era grading machines, drawn by 26-h.-p. traction engines, or by 12 mules, each, when the ground was soft. These graders loaded the excavated materials into three-horse contractors' dump wagons in which it was hauled through openings left in the walls and filled in behind the latter on the layer of puddle which had already been placed against the wall.


Concrete Mixing Outfit and Forms for Basin Walls.

Some puddle has been placed and the concrete lining laid over a portion of the bottom of the basins. The same concrete mixing outfits used in building the footings for the walls are being used in placing the concrete bottom lining. The bottom is laid in blocks 8x8 ft. in plan, and with ½-in. joints between them, as required. These blocks are placed continuously, ½x9-in. by 8-ft. iron plates forming the joints. These plates are greased with paraffin and tallow to aid in pulling them, the pulling being done with a light lever jack at each end.

The construction of the basins, according to the plans, requires approximately 50,000 cu. yd. of puddle under the concrete lining of the bottom and as backing for the walls. This puddle is made from a very excellent deposit of yellow clay excavated from the top of a high bluff back of the low-service pumping station, and about half a mile from the transverse dividing wall of the basins.


Removing Forms from the Rear Face of the Basin Walls.

A very complete plant for excavating, mixing and delivering the puddle has been installed. A New Era elevating grading machine, drawn by a 26-h.-p. traction engine, is used in excavating the clay and loading it into three-horse bottom-dump contractors' wagons. The clay is hauled in these wagons to pug mills at the edge of the bluff. Three of these mills, 8 ft. long, and of the Freeze & Co. type are used as dry granulators into which the clay is dropped from the wagons through three traps in a platform over the mills. The granulators each feed the clay into one of the pug mills proper, which are 12 ft. long, where water is added in a fine spray. The wet mills discharge at the ends into 3-yd. dump cars on a 36-in. gauge track. This track has two branches just below the pug mills, which branches drop down the side of the bluff on a grade varying from 6 to 33 per cent. for a distance of 1,000 ft., part of this grade being on a trestle over a highway. The dump cars are operated on the incline in trains of three by a cable railway, the descending loaded cars assisting in pulling the empty ones to the top of the incline. The tracks at the bottom of the incline connect with tracks leading to the basins, the cars being handled in trains of 6 to 9 over 2½ per cent. grades by 9x14-in. locomotives running on 30-lb. rails.

The cars in which the puddle is delivered are designed specially to handle this material. They are side-dumping and tilt to an angle of 55 deg. The bottom of each car extends out 1 ft. on each side farther than is usual in such cars, in order to cause the puddle to slide beyond the ends of the 6-ft. ties in the tracks. The bottoms of the cars are lined with No. 12 sheet steel to prevent the puddle from sticking. The cars were furnished by the Western Wheel Scraper Co., of Aurora, Ill., and have given satisfactory service in handling the wet, sticky puddle used on the work.

The puddle back of the basin walls is dumped into place from cars operated on a narrow-gauge track laid on top of the walls. These cars are hauled out on top of the walls in trains by the locomotive and dumped with no more difficulty than is experienced in dumping ordinary material in the same manner from cars of the usual type. The puddle for the bottom of the basins is hauled into the latter, on the narrow-gauge tracks, in the cars in which it is delivered and is dumped directly in place from these cars.

The construction of the two new basins and the improvements directly connected with them are about 60 per cent., completed, and it is believed they can be finished and placed in service by the end of 1907. The principal quantities of materials required in their construction are as follows: 230,000 cu. yd. of excavation; 49,700 cu. yd. of puddle; 40,150 cu. yd. of concrete; 17,000 ft. of ½-in., 1,103,000 ft. of ¾-in. and 35,000 ft. of 1-in. Johnson corrugated reinforcing bars; 4,100 ft. of permanent standard-gauge railroad track; and 3,050 ft. of sewers.

Mr. Ben C. Adkins, water commissioner, of St. Louis, has general supervision of the improvements which are being made by the water department. Mr. Edward E. Wall, assistant water commissioner, has charge of the engineering work for the department. Mr. Arthur I. Jacobs is engineer of the supply and purifying division of the water department in which division the improvements described are being made. The basins are being built by Messrs. Fruin & Colnon, general contractors of St. Louis, for whom Mr. A. P. Greensfelder is superintendent in charge of field operations at the Chain of Rocks.

Rail Corrugations were discussed at considerable length by Mr. Joseph A. Panton, in a paper before the Institution of Electrical Engineers, in which these corrugations are attributed to lateral play in weak trucks, the weakness being intensified by unsymmetrically driven axles. In the discussion of the paper, Mr. H. M. Sayers suggested that a considerable part of the trouble might be due to slipping of wheels on curves or when braked.

A New Impact Test.

A paper read before the American Society for Testing Materials by L. W. Page, director of the Office of Public Roads, Department of Agriculture.

The essential parts of this impact machine, like all others, are a hammer and an anvil. The nature of the work for which it is designed, however, has made it necessary to introduce a number of devices not before employed in impact tests.

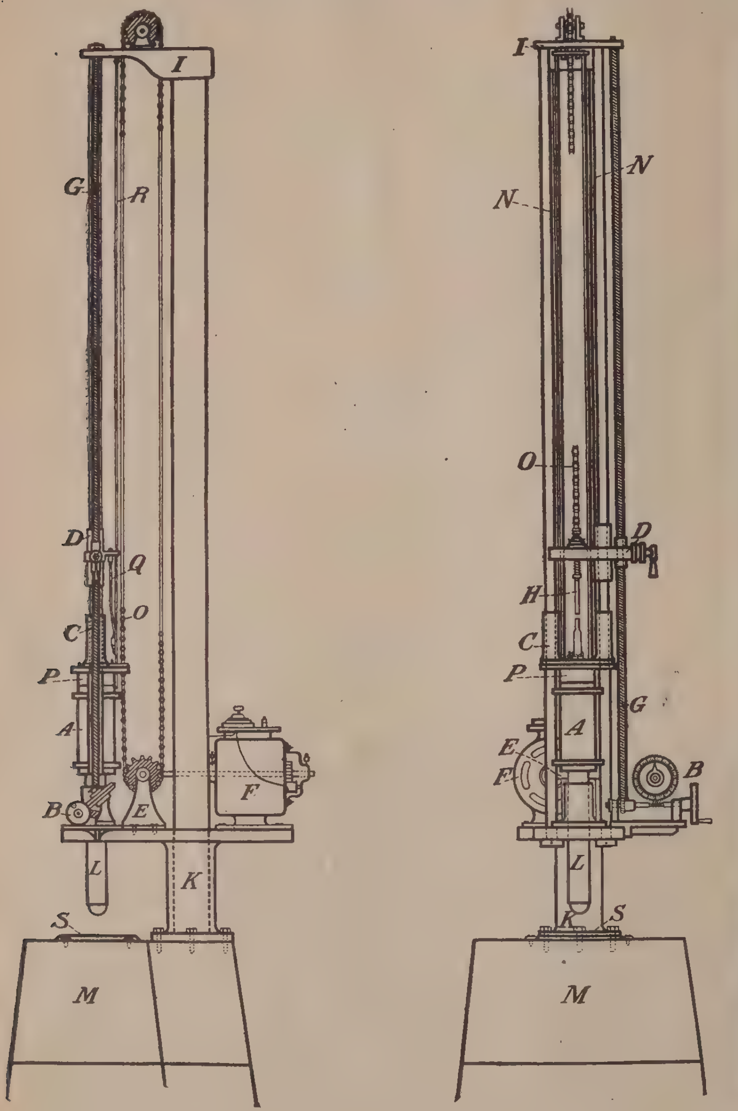
The main object of the test is to determine the relative toughness of road-building rocks. In the consideration of road materials toughness is understood to mean the power possessed by a material to resist fracture under impact. As the surface of a road is continually subjected to the pounding of traffic, it can be seen that toughness is an important property from the standpoint of the road builder. From the laboratory standpoint the problem is not altogether a simple one, and considerable difficulty has been found in designing a suitable test for measuring the degree to which a rock possesses this property. With homogeneous, structureless, brittle materials, resistance to impact may be due to a relatively low modulus of elasticity combined with high elastic limit. Provided a blow is delivered on such a material by a flat striking head with small local damage, toughness will be almost wholly due to elasticity. In this case there will be a critical energy of blow below which the specimen under test will not be broken by an indefinite number of blows, and in excess of which it will be broken by a single blow. The toughness of a road material in this instance will vary directly as the square of the elastic limit, which equals the ultimate strength, and inversely as the modulus of elasticity. In testing such materials under impact it is necessary to apply a number of blows of successively increasing energy and note the blow causing failure. The machine which I am about to describe involves this principle, and is the result of about fourteen years' work on the subject.

Instead of the hammer falling directly on the test piece it strikes an intervening plunger and the energy of the blow is conveyed through this plunger to the test piece. As comparative values are sought rather than physical constants, the end of the plunger bearing on the test piece is spherical in shape, thus rendering the energy of the blow splitting in its effect. At present we have in the laboratory of the office of public roads two of these machines, one having a 2-kg. hammer and a 50-kg. anvil, photographs of which are given here. This machine is used for making routine tests on the toughness of road-building rocks, and has a few special devices for this work. The other machine has a 10-kg. hammer and a 500-kg. anvil, and is used for larger tests, especially on paving blocks. A front and side elevation of this machine are also given. In describing this test I will confine my remarks entirely to the smaller machine, as it has all the essential parts of the other and a few improvements.

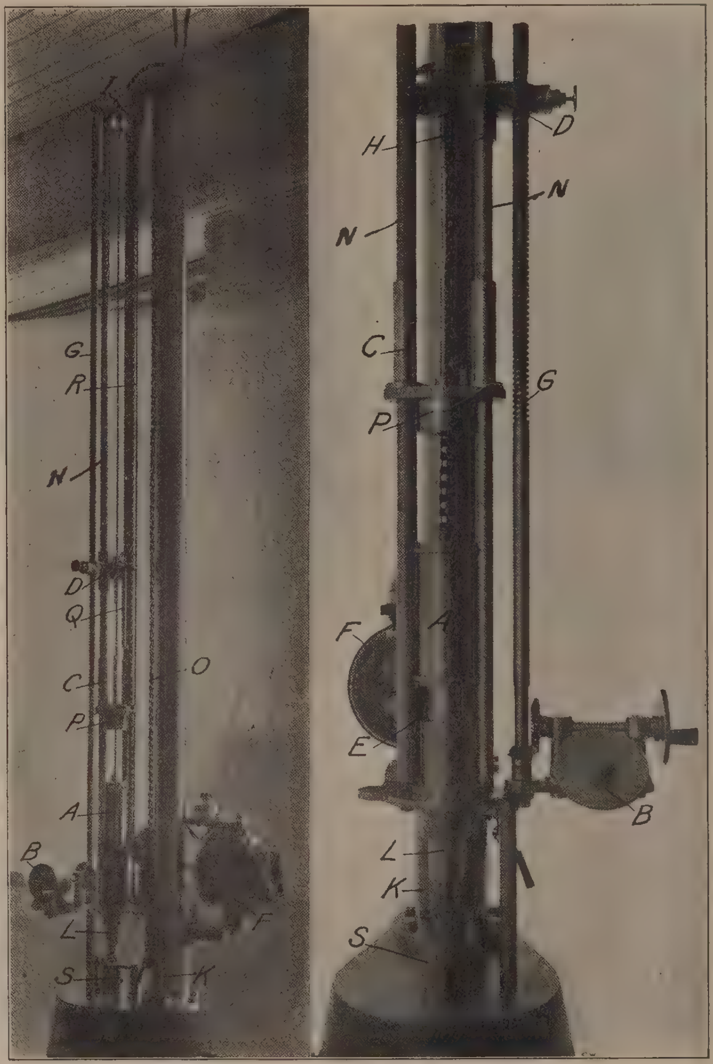
The test for toughness is made on 25x25 millimeter rock cylinders, which are cut with a core drill. It can be seen that the blow as delivered through a spherical end plunger approximates as nearly as practicable the blows of traffic; besides this, it has the further advantage of not requiring great exactness in getting the two bearing surfaces of the test piece parallel, as the entire load is applied at one point on the upper surface. The test piece is adjusted so that the center of its upper surface is tangent to the spherical end of the plunger, and the plunger is pressed firmly upon the test piece by a spring. The test piece is held on the anvil of the machine by a device which prevents its rebounding when a blow is struck by the hammer, and which keeps the test piece centered.

The hammer, which weighs 2 kg., is raised by a sprocket chain and released automatically by means of an electromagnet. The test consists of a 1-cm. fall of the hammer for the first blow, and an increased fall of 1 cm. for each succeeding blow until failure of the test piece occurs. The number of blows required to destroy the test piece is used to represent the toughness of a sample. The variation in results on the same material is very low; only in rare instances does a variation of more than one blow occur.

The machine consists of a 2-kg. hammer, *A*, which is guided by two vertical rods, *N*. The upper end of the hammer has a small cone set in it, which fits snugly into a concentric electromagnet, *P*, the latter being attached to the lower side of a crosshead, *C*, which slides freely on the guide rods. *N*. This crosshead is provided with a slot on its rear side through which a sprocket chain, *O*, passes. This sprocket chain is supported on two sprocket wheels which are attached to castings at the top, *I*, and near the base, *K*,



Large Machine for Impact Tests.



Small Machine for Impact Tests.

of the machine, which project sufficiently to support the guide rods, *N*, and other attachments. The lower sprocket wheel is directly connected by a worm gear to an electric motor, *F*, placed at the rear end of the lower casting, *K*. The sprocket chain is provided with two small lugs, which, when it is being driven by the motor, engage a spring bolt attachment, which projects inward on either side of the slot on the crosshead, *C*. This raises the crosshead until tripped by a rod, *O*, projecting downward from an upper crosshead, *D*. When this takes place the crosshead, *C*, which holds the electro-magnet falls until it comes in contact with the hammer, *A*. The electro-magnet, *P*, is supplied with current from the same circuit running the motor. The current is conveyed through two small conducting rods running parallel to the guide rods, both being insulated from the rest of the machine. The current passes from one of these conductor rods through a small carbon brush to a make and break attachment, *H*, on the upper crosshead, *D*, and thence down one of the guide rods through the electro-magnet back to the other conductor rod.

When the crosshead, *C*, is raised by the lugs on the sprocket chain and the current turned on the magnet, the hammer is lifted until the crosshead, C, comes in contact with the make and break, *H*, on the crosshead, *D*, and thus releases the hammer, which falls, striking a plunger, *L*. This plunger is made of armor-piercing steel which has the maximum temper at its lower end, which is spherical in shape. The test piece rests on a counter anvil, S, of hard steel, the plunger resting on its upper surface, which is tangent to it at its center point.

The upper crosshead, *D*, is raised through any desired height by means of the long revolving screw, *G*, which is geared at its lower end to a dial, *B*, on which the height of the make and break attachment, and, therefore, the height of the hammer drop may be read direct. By means of the revolving dial and screw the height of the crosshead may be adjusted by very close approximation to within 1 millimeter.

In order to prevent the crosshead, *C*, which holds the electro-magnet from striking too hard a blow on the hammer when falling a dash-pot was first used, but we have found that a few drops of cylinder oil on the lower end of the guide rods completely prevents this difficulty.

A point of interest in connection with this test is the fact that many of the test pieces are split into three pieces. Just why this takes place I am unable to explain.

The highest result yet obtained was on a sample of diabase from Pennsylvania. One test piece of this sample broke at a drop of 54 cm. Three months later another operator cut and tested another test piece, which broke at 58 cm. drop. The next highest result was on a fine grained sandstone from Virginia. One test piece broke at 49 cm. and the other at 50 cm. drop. I give these results only to show the small variation in results on the same materials. In rocks of low toughness there is generally no variation.

Several series of cement briquettes, of the same size as the rock cylinders, have been broken in this machine, with practically no variation in the results. It was necessary in these tests to use a ½-kg. hammer to give high numerical values to the results. This test has also been found most useful in grading asphalt surface mixtures. Some interesting penetration tests have also been made on wood paving blocks.

In concluding, I may state that a very interesting series of tests are at present being made to determine the detonating points of the high explosives. It has already been ascertained that more energy of blow is required to detonate nitroglycerine than a number of the other high explosives. It is very easy with this machine to determine the detonating point of an explosive at a given temperature within 1 cm. fall of the hammer. Nitroglycerine, for instance, detonates at 30 cm. drop at 29°, 31 cm. at 28°, 34 cm. at 24°, 35 cm. at 23°, 67 cm. at 11°, and 95 cm. at 8°.

Foundations of the American Bank Note Building, New York.

The new 66 x 44-ft. office building for the American Bank Note Co., New York City, will be a fireproof steel cage structure at the corner of Broad and Beaver Sts. Above the street level the floors are entirely unobstructed by columns and, together with the roof and walls, are carried on 16 steel wall columns. Eight of these columns in two opposite sides of the building have separate rectangular piers from 6½ to 7 ft. square. On a third side of the building the four columns are carried in two pairs, each on long, narrow piers, and on the fourth side, where the columns are located close to the wall of the adjacent building, they are supported on separate still smaller and narrower piers close to the footings of the old building. All of the piers are of concrete carried down by pneumatic caisson process through quicksand and some clay to a solid stratum of hardpan from 30 to 37 ft. below the curb. The column loads are distributed on the tops of all of the larger caissons by double grillages consisting of a lower tier of I-beams and an upper tier of pairs of channels riveted together back to back to give larger web sections than can be secured in I-beams of the same depth.

The self-supporting brick wall of an adjacent four-story building on one side of the lot was underpinned by seven 12-in. wrought-iron sectional pipes driven to hardpan by the Breuchaud method before the excavation was commenced. The pipes were received in 6-ft. lengths and were sunk in the usual manner with a hydraulic jet and a 50-ton hydraulic jack, reacting against the wall of the building. They were forced down to refusal against the hardpan, the interior was thoroughly washed and pumped out and filled with concrete, and the work was completed without entering the interior of the old building or causing any settlement or cracks in its wall.

The site was excavated by hand to a depth of about 11 ft. below the curb and the spoil was removed at first in wagons driven into the excavation and afterwards by derricks and buckets. The sides were retained by 2-in. tongue-and-groove sheet-piling braced by inclined struts as the excavation was carried down and afterwards left permanently in position and faced up on the inside with a concrete wall reinforced by steel rods ⅞ in. in diameter. Ground water was encountered at a depth of about 9 ft. below the curb and was drained by syphons to one of the caissons, which was left unfilled until the last to act as a sump and was emptied by a 4-in. centrifugal pump driven by an electric motor.

One one side of the lot a working platform at street level was built on falsework bents and on it was mounted a stiff-leg derrick with a 50-ft. boom of 15 tons capacity which commanded all portions of the lot and unloaded the caissons of a maximum weight of 7 tons from wagons in the street and delivered and set them in their required positions in the excavation. The derrick was operated by a 7 x 10-in. double drum Lidgerwood hoisting engine with independent boiler and sufficed to handle all materials involved in the construction of the substructure. Underneath the derrick platform were set two 10¼-in. class E Ingersoll-Sergeant air compressors and their receivers, and the remainder of the space there was utilized for storage and workshops.

The 8 regular piers were sunk with standard rectangular wooden caissons very simply constructed with 3-in. vertical sheeting with caulked joints, bolted to inside rectangular horizontal frames made of 4 x 12-in. planks, spaced from 16 to 34 in. apart vertically in the clear. A deck of two crossed courses of 3-in. planks, 6 ft. in the clear above the cutting edge, is supported on the upper edge of one of the interior frames and another frame was bolted in contact with its upper surface. A steel airshaft 3 ft. in diameter was fitted to the deck and provided with the usual air-locks and connections. The lower horizontal frame was made of 6 x 10-in. timbers and being placed 6 in. in the clear above the cutting edge served to reinforce the latter which was formed simply by bevelling the lower ends of the wall sheeting which were not shod or otherwise strengthened. The vertical sheeting was made in 18-ft. lengths continuous over the working chamber and the cofferdam.

When this did not suffice, the cofferdam was extended by a separate 8-ft. section constructed in the same manner and connected to it by ¾-in. vertical bolts through the top frame of the lower section and the lower frame of the upper section which thus acted as flanges. The sheeting in the lower section extended about an inch above the upper edge of the upper cross frame and thus formed a socket to receive the lower edge of the lower frame in the upper section, the sheeting for it being cut short to correspond and bringing the joint over the solid timber of the lower cross frame in the upper section. Two of the caissons about 19 ft. long and 4 ft. wide were made in substantially the same manner except that the long side frames were braced by two sets of equidistant 3 x 10-in. horizontal transverse struts. The smallest caissons, 3 ft. 8-in. x 8 ft. 4 in. outside, were constructed substantially like the regular caissons except that in order to increase the clearance for the airshaft made with 5-ft. sections of 3-ft. cast-iron cylinders with inside flanges, sections about 2 ft. long were cut out of the center of each of the long sides of the inner horizontal frames and the remaining end pieces were spliced together with single 8 x ⅜-in. plates 46 in. long, thus increasing the effective width of the caisson nearly 6 in. The caissons were filled with 1:3:5 concrete made with Atlas Portland cement hand-mixed and completed in 25 days with an average force of about 90 men.

Kirby, Petit & Green were the architects. Mr. Chas. H. Nichols, consulting engineer, and the Hedden Construction Co. general contractor. The Bryson-Gamble Co., was the contractor for the sub-structure work above described.

The Preservation of Ties by crude oil has been tried successfully by the Atchison, Topeka & Santa Fe Ry. In the fall of 1901 the company treated a few thoroughly seasoned New Mexico, Arizona and Texas pine ties with California crude oil containing about 75 per cent. asphaltum base, the remainder being light oils, the greater part of which vaporized when heated. The oil was heated to 180° Fahr. and forced into the wood under a pressure of 150 lb. per square inch, the ties taking up from 4 to 8 gal. each. They were placed in an experimental track on the Gulf, Colorado & Santa Fe Ry., where an untreated loblolly tie will not last over two years, and an untreated long leaf tie not over three years. The ties were examined by the Santa Fe officers after they had been in service four years and nine months and were found perfectly sound. Those that were sawed through or bored were found to be in excellent condition, and the spikes were not only as good as the day they were driven, but seemed to hold better than in untreated ties. The company has therefore decided to use oil for ties, and to continue creosoting for bridge timbers and piling.

Aqueduct Bridges on the Illinois and Mississippi Canal.—II.

By Fred W. Honens, M. Am. Soc. C. E., Junior U. S. Engineer.

Methods of Construction.—Aqueducts 1 and 9 were built entirely by hired labor, as were also the piers and abutments of Aqueducts 2 and 3, and the trunks, including the reinforced concrete linings, of all of the aqueducts.

The foundations of Aqueducts 2 and 3 were constructed by Cogan & Pound, contractors, and the foundations of Aqueducts 4 to 7, inclusive, were put under contract twice, it being finally necessary for the Government to complete the work by hired labor. The foundation of Aqueduct 8 and the piers and abutments of Aqueducts 4 to 8, inclusive, were constructed by Page & Shnable, contractors, of Chicago. The latter contract was completed during the season of 1906.

Unless otherwise stated, the methods of construction described were those used at Aqueduct 9. The methods used at Aqueduct 4 are typical of the work done on the Western Section and will be referred to frequently. Junior Engineers H. E. Reeves and A. O. Rowse were the resident engineers in charge of construction of Aqueducts 4 and 9, respectively.

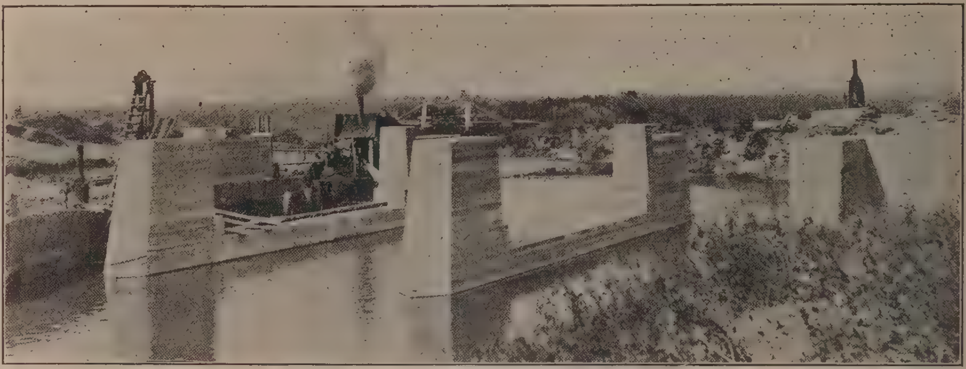
Aqueduct 9 is located about 11 miles from Tampico, Ill., its nearest railroad station, and 24 miles from Rock Falls, Ill. A narrow-gauge railroad was previously constructed by the Government for riprapping the banks of the canal, and was later extended to the Aqueduct. All of the materials were received at Rock Falls, and transported to the aqueduct with a construction train. There is a siding from the Chicago, Burlington & Quincy Ry. on the canal right-of-way at Rock Falls.

Aqueduct 4 is located about 2 miles north and east of Mineral, Ill., which is a station of the Rock Island Ry.

The canal runs almost due south at Aqueduct 9, making an angle with Green River, such that during construction, an abutment and the upper end of one pier were on the south side of the river, two piers were entirely in the river, and an abutment and the lower end of one pier were on the north side of the river.

A cofferdam about 110 ft. long was built parallel to and about half way between the first and second piers, from the north, with a wing on the upstream side that returned to the river bank. In the same way a dam was built between the third and fourth piers with a wing on the downstream side that returned to the south bank, thus leaving a channel about 65 ft. wide for the passage of the river.

The coffer-dams consisted of two lines of sheeting, 2 x 12-in. by 8 ft., placed 6 ft. apart, filled with a sandy loam, the only available material.



Right-Hand End of Aqueduct No. 4.

Left-Hand End of Aqueduct No. 4.

Each line of sheeting was supported by two 6 x 8-in. by 16 ft. horizontal waling timbers, placed about 4 ft. apart. Vertical 6 x 8-in. posts were placed outside at the ends and center of the wales, through which the coffer-dam was tied together at top and bottom with ⅝-in. rods, 8 ft. 6 in. long.

After all of the work inside of the two enclosures, including the excavation for the channels, had been finished, the wings of the dams were removed and the ends of the main or longitudinal portions were connected with cross-dams, thus enclosing the second and third piers and forcing the water through the two side channels.

Twice it was necessary to flood the pit on account of high water. This was accomplished through a sluice or trough about a foot square, with a gate, constructed in the cofferdam about 2 ft. above the ordinary water line. The gate was kept closed until it was seen that the dam was in danger, when it was opened, allowing the pit to flood.

Owing to the sandy bottom of the river, the cofferdams were not entirely satisfactory. Twice the water went under the sheeting, doing no particular damage except to delay the work for a few days. On later work a pile coffer-dam was used.

Such a coffer-dam was constructed at Aqueduct 4 by driving a row of round piles 7 ft. apart, through the center of the creek between the second and third piers, to which was bolted 6 x 8-in. waling timbers.

Triple-lap sheet piles made of 2 x 12-in. by 16-ft. lumber were driven about 8 or 9 ft. and spiked to the wales. At each end of the pit a similar dam was constructed across the channel, sluiceways being left on each side of the center coffer, which could be closed with planks when it was desired.

The materials excavated at Aqueduct 9 were sand and sandy peat with some clay. The work was done with teams and scrapers, except the sand in the middle section, which was excavated with a 6-in. sand pump. The materials were wasted between and back of the canal embankments, which had been previously built, the bottom grade of the canal being several feet above the natural surface of the ground.

At each aqueduct, channels were excavated across the canal right-of-way, being the full width between abutments except where it joined the original channel.

The first contract for excavation and building foundations for Aqueducts 4 to 7 inclusive on the Western Section, was dated March 20, 1902. The only work done at Aqueduct 4 under this contract, was the excavation of about 11,000 cu. yd. of materials.

The work was relet on Oct. 12, 1903, but no work was executed at Aqueduct 4 under this contract. When the United States began work by hired labor, in the spring of 1905, to complete these contracts, the pit was found to have from 7 to 9 ft., about 7,000 cu. yd., of silt deposited in it. This deposit stood at a slope of about 1 to 4, and was gummy and sticky, being exceedingly hard to dump from the cars.

The hired labor work was done with a ¾-yd. Page scraper bucket operated by a stiff-legged derrick mounted on a frame with a 12-h.-p. hoisting engine and vertical boiler, which furnished the power. The dredge was moved about on rollers.

The excavated materials were dumped into 1¼-yd. dump cars, which were pulled to the top of the canal bank with a cable by a 15-h.-p. hoisting engine. The cars were operated in trains of three cars each. At the top of the embankment, the train was taken by a team and drawn down the canal where the materials were dumped back of the canal bank. A force consisting of 2 enginemen, 1 fireman, 1 team, 6 laborers, and a foreman, operated the plant. The output was about 15 cu. yd. per hour.

Both round and sheet piles were driven with a driver having a 2,000-lb. hammer, aided where necessary by a water jet. The round piles were about 16 ft. long and 12 to 16 in. in diameter at the large end, the average driven length at Aqueduct 4 being between 14 and 15 ft. A sheet pile was made of three pieces of 1½-in. white oak 8 ft. long, fastened at the top and bottom with three 5 x ¼-in. boat spikes, making a tongue and groove 2½-in. deep. The sheeting was driven about 7 ft. below the bottom of the foundation, and was imbedded about 6 in. in it. The round piles were cut off at grade, the longitudinal timbers placed and the spaces between timbers filled with concrete. The cross timbers were then laid and concrete filled between them.

At Aqueduct 4, the concrete was made with Utica natural cement, the proportions being 1 part cement, 2 of Mississippi River sand and 4 of crushed limestone from quarries at Moline, Ill. The concrete was mixed with a one-half yard Smith mixer, and dumped into the pit, where it was distributed in the foundations with wheelbarrows. The materials were placed in the mixer with wheelbarrows.

Assembling Steel at Aqueduct No. 8.

At Aqueduct 9, Portland cement was used almost exclusively, most of it being the Marquette brand. The sand contained about 20 per cent. of pebbles and was obtained from excavations from the canal prism. The crushed rock was obtained from the Government crushing plant at Rock Falls, being screened to remove dust and rock too large to pass a 2-in. ring. The concrete in the foundation consisted of 1 cement, 3.5 sand, and 4.5 crushed rock, and was mixed with a half-yard Smith mixer as later described for piers and abutments.

The concrete materials for the piers and abutments of Aqueduct 9 were the same as for the foundations and were hauled to the site of the aqueduct in dump cars. The track was on top of the canal bank from which the cars were dumped on the outside of the bank, the slope being covered with a grass sod. Enough sand and crushed rock was delivered before any construction began to complete all of the concrete work. The materials were distributed along the bank for a distance of about 400 ft. An accompanying illustration shows the general layout of the mixing and hoisting plants.

Placing the Concrete Lining at Aqueduct No. 9.

A warehouse with a capacity for storing about 2,000 bbl. of cement was rebuilt about 1,500 ft. from the aqueduct and a shed was built over the track at the aqueduct site large enough to shelter a flat car loaded with cement. All cement was received in sacks.

Progress View during the Work of Lining Aqueduct No. 7.

The concrete was mixed in a one-half yard Smith mixer mounted on a frame with an engine and vertical boiler, the concrete proportions being 1 cement, 3.5 sand and 4.5 crushed rock. The materials were loaded into a car, in which they were measured, the sand being placed in the bottom and the rock on top, with the cement sandwiched between. The car was designed and built for use on the concrete work on the canal. It consists of a wooden hopper lined with sheet steel, having a slide in the bottom for dumping, mounted on two pairs of trucks of 36-in. gauge. Its capacity is about 20 cu. ft. The car was pulled up an incline by a single horse to a platform above the mixer, where it was dumped through an extension chute into the machine and mixed.

The concrete was dumped from the mixer into one of the concrete cars described, which was pushed onto an elevator and hoisted to a trestle where it was pushed by two men to the form where the concrete was deposited. In order to provide a passageway for cars without using switches, a track just long enough to hold one concrete car was constructed, at the same elevation as, and on the opposite side of the elevator, from the track leading to the forms. Two cars were used for carrying the concrete, one car being at the mixer when the other was on the upper concrete track. The cage of the elevator would be left at the top, making a continuous track over the elevator, and the car from above would be run over it to the passageway. The cage would then descend, the car of concrete be placed thereon, and raised to the upper track. As soon as the loaded car was pushed off, the empty one was pulled on and lowered to the mixer, and the operation repeated. For every load of concrete taken to the forms, it was necessary to raise the cage twice. In this way, the elevator man also acted as switchman.

The mixer was placed about 50 ft. below the downstream end of the piers and a trestle was built from the elevator, which stood just in front of the mixer, to the forms, a track being laid on it extending from end to end of the several piers and abutments.

The forms were built with posts of 6 x 8-in. timbers and the lagging of 2 x 12-in. pine plank, surfaced on two sides. The posts were placed opposite on the two sides and 4 ft. between centers. They were tied together at the top about 2 ft. above the concrete with a 3 x 12-in. plank and at two intermediate points between top and bottom by ⅝-in. rods. Planks were spiked to the grillage timbers to catch the heels of the posts, and the upper tie carried the concrete track.

The piers were divided into two sections by a bulkhead at about the center of the forms. The abutments were built in six sections, the two parts of the breast wall being first, the canal retaining walls next, and the wing walls last.

The work was carried on by two shifts of 8 hours each. No special effort was made to complete the work as a monolithic structure, but at the close of work on the second shift, the concrete was leveled and tamped as nearly horizontal as possible. The masonry was not faced, the concrete being thrown up against the sides of the form, allowing the coarser parts to rebound, and the crushed rock was omitted from the last batches on top.

The piers and abutments at Aqueduct 4 were built with natural gravel and the Chicago AA brand of Portland cement. The specifications for cement were those formulated by a Board of Army Engineers and published as "Professional Papers No. 28, U. S. A."

The following extract is from the specifications for concrete, and proved to be quite effective:

"Abutments and piers of aqueduct bridges shall be built of Portland cement concrete so proportioned that there are no voids when compactly rammed, and shall contain on an average, for each section of wall, one and one-tenth barrels of Portland cement per cubic yard in place, including facings, copings, and bonding layers, as hereinafter described. In no case will a greater proportion of sand than three parts sand to one part cement be permitted to be used. In case the number of barrels in any piece of masonry falls below the average stated above, then the price per cubic yard shall be reduced in proportion to the reduction in amount of cement used. Prices of concrete will not be increased if greater quantities of cement than specified above per cubic yard are used.”

The gravel contained about 55 per cent. of pebbles and the proportions for concrete were made 1 cement to 5½ gravel.

The concrete was mixed in a 1¼-yd. Page mixer, an invention of Mr. J. W. Page, one of the contractors. It is an open drum batch mixer mounted on the end of a shaft inclined at an angle of 52 deg. with the vertical plane. It is operated by spur and bevel gearing by a 20-h.-p. two-cylinder vertical reversing engine. Its capacity is about 15 batches per hour.

A platform was built around the drum of the mixer, on which the cement was unloaded. The gravel (27 cu. ft.) was loaded into a 1¼-yd. side-dump car and pulled up an inclined track by a 20-h.-p. double-drum hoisting engine, onto the platform in front of the mixer, where it was dumped into the drum with five sacks (5 cu. ft.) of cement.

The concrete was dumped through a door in the side of the drum into a hopper concrete car with bottom dump, and hauled to the forms by a cable operated by the second drum of the hoisting engine previously mentioned. A small trestle was built from the mixer to the form and the concrete car was pulled up an incline, about 22 ft. long with a rise of about 10 ft., to a track on top of the form. This allowed the distribution of the concrete along the entire length of the pier or abutment.

Concrete Plant and Trestles at Aqueduct No. 9 in 1904.

Mixing Plant Used in 1905 for Lining Aqueduct No. 9.

The forms were built about the same as at Aqueduct 9. The form for the nose was built in two pieces, which were left intact when wrecking the forms. The short planks in the nose were beveled to fit the corners and were spiked to 6 x 8-in. posts. The two pieces of the nose forming were fastened together where they met by bolts through the posts. The posts were also supported by diagonal braces from the ground.

The concrete would be considered a wet mixture. All of the exposed surfaces were faced with a mortar of 1 cement to 2 Mississippi River sand, 1½ in. thick.

The piers were divided into two sections, each of which were built in one day.

The materials for the concrete lining for Aqueduct 9 were the same as used for the piers and abutments, although crushed rock was not used except for the concrete over the piers. Marquette Portland cement was used exclusively.

The same one-half yard Smith mixer was used for mixing the concrete, but with an entirely different set up. The mixer was placed at the bottom of the canal between the embankments, and a short track for a material car was constructed over it. Over this track and at a height sufficient to clear one of the concrete cars, a hopper having a capacity of 6 or 7 cu. yd. was built. The hopper was about 9 ft. square at the top and had a 12 x 18-in. cast-iron chute with steel slide in its bottom which was opened and closed by a lever. The hopper was placed adjacent to the track on the canal bank. The sand or gravel, which had been stored on the opposite side of the canal bank the previous year, was loaded into 3-yd. dump cars and hauled with the narrow gauge locomotive by a circuitous route to the hopper, where it was dumped. From here the gravel was dumped into the material car where it was measured and pushed by hand to and dumped into the mixer. The concrete was dumped from the mixer onto a platform, where it was shoveled into wheelbarrows and wheeled to the forms.

The ends of the floorbeams and trusses are embedded in concrete, 4 ft. wide and 18 in. thick, over which the joint in the lining between the adjacent bays is made. This joint was made by placing a piece of house siding between the two pieces of concrete when it was built, subsequently removing it and filling the joint with coal tar pitch. As just indicated, the lining for each span was built separately, the floor and those parts of the side up to the top of the triangular reinforcement being built one day and the balance of the sides later.

For the floor forming, 2 x 12-in. by 8-ft. pine planks were laid horizontally between, and were supported from, the flanges of the floorbeams by small horses or brackets.

For the side forming, vertical posts were securely fastened between the two beams of the side truss every 4 ft., and 2-in. lagging nailed to them. To form the triangular portion, diagonal posts of 3 x 8-in. pine were nailed to the top of the vertical post, extending downward to the top of the floor lining, and were wired to the opposite side of the form. The lagging was placed under these diagonal posts as the concrete was deposited.

All of the reinforcing bars in the floor were laid in position and wired together the day before the concrete was deposited. At the same time, the vertical reinforcing bars for the sides were bent to a template and were wired at the top to a 2 x 4-in. strip. The horizontal bars were laid in position as the concrete was deposited.

Operations were begun on one of the sides, the first layer of concrete extending several feet beyond the side into the floor, on which a working platform was built. This consisted of three lines of 3 x 12-in. plank laid close together parallel to the side and on top of the fresh concrete with 2-in. strips laid crosswise thereon and a fourth plank carried on the strips.

A runway for filling the sides was supported from this plank. As the concrete was being deposited in the side, a second smaller gang of men kept the floor bond alive. This was done by placing a 2 x 4-in. strip on edge over the center of the floorbeam and depositing concrete between it and the concrete previously deposited with which it was bonded. The strips were 2 ft. 3 in. wide and extended the full length of one span of the aqueduct. When the first side had been completed to the top of the triangular section, the same operation was repeated on the other side, and a third small force kept the floor bond alive on that side. As soon as the second side had been completed, the entire force was concentrated on the floor.

The concrete was a wet mixture and was finished with a wooden float, no additional mortar being used.

At Aqueduct 4, 1.8 bbl. of Marquette Portland cement were used with 1 cu. yd. of bank gravel. The Smith concrete mixer was placed at the bottom of the canal with its hopper against the inside wall of the abutment. It was charged by one-horse dump carts from the top of the abutment walls.

The method of construction was practically the same as previously described. The concrete was deposited the middle of December, in freezing weather, the lowest temperature being 12° Fahr. The water for concrete was heated to about 130° Fahr., the exhaust steam from the mixer engine was discharged into the mixer, and the concrete was deposited at a temperature of 70° to 90° Fahr.

After the concrete was deposited, boards were laid on the fresh concrete to support carpenters' horses. Planks were placed between the horses, the entire area over the lining was covered with inch boards, and the space heated for about 48 hours with live steam.

The concrete deposited in freezing weather was apparently as good as any of that deposited in mild weather.

Each of the piers at Aqueduct 4 contain 191.5 cu. yd. of concrete and each abutment 350.5 cu. yd., a total of 1,467 cu. yd. There were 1,801 bbl. of Chicago AA cement used in the concrete besides 113 bbl. in the mortar for facing. The splay walls at the ends of the aqueduct contain 119.88 cu. yd. of concrete and required 159 bbl. of Chicago A A cement in their construction. The contract price for Portland cement concrete was

$7.07 per cubic yard. The total cost of the masonry, including splay walls, was $11,219.24.

The unit costs for materials and labor for the earthworks, foundations, piers and abutments at Aqueduct 9 amounted to 31 cents for 16,471 cu. yd. of excavation, 25.1 cents for 7,000 cu. yd. of back-filling, $5.92 for 632 round piles, $64.75 per thousand feet for 18,616 ft. B. M. of sheet piling, $38.81 per thousand feet for 40,050 ft. B. M. of grillage, $6.66 for 3,612 cu. yd. of concrete, and $3.70 per linear foot for cofferdams. In addition $1,645.15 was spent for engineering connected with these items, $1,663.85 for pumping and $1,485.92 for the emergency gates set in place. The unit costs for the superstructure, splay walls and lining at the same structure were 2.3 cents for 427,889 lb. of steel in the superstructure, $6.217 per yard for 206 cu. yd. of concrete in splay walls, $8.702 per yard for 329 cu. yd. of concrete in the lining and 2.32 cents for 30,924 lb. of reinforcing metal. The engineering cost $715.

Two Typical Transmission Line Views, Taylor's Falls Development.

The following is the scale of wages for the above work, 8 hours constituting a day: Overseers, $100 per month; locomotive enginemen, $90; pump enginemen, etc., $60; stokers, $60; watchmen, $45; teamsters with teams, $3.50 per day; capenters, $2.50; laborers, $1.75; waterboys, 60 cents.

The average cost of 35 spans of the reinforced concrete lining of the aqueducts is $756.87 per bay, and the average cost of the concrete is $9.48 per cu. yd.

The work of construction of all work on the feeder and Western Section of the canal has been in charge of Assistant Engineer L. L. Wheeler, and that on the Eastern Section in charge of Assistant Engineer J. C. Long. Major W. L. Marshall, Major J. H. Willard, Major C. S. Riché, and Lieut-Col. W. H. Bixby, Corps of Engineers, U. S. A., have had supervision successively of the work in the district in which the canal is located.

My thanks are due Messrs. Wheeler, Rowse and Reeves for help in preparing this article.

Cofferdam Used in Building Closing Section of Spillway.

A HIGH-VOLTAGE THIRD-RAIL INTERURBAN LINE is under construction in California between Marysville and Nevada City and Auburn, using a protected under-running conductor rail on private right of way and overhead wire and pantagraph trolley in public streets. The operating voltage is 1,200 volts direct current.

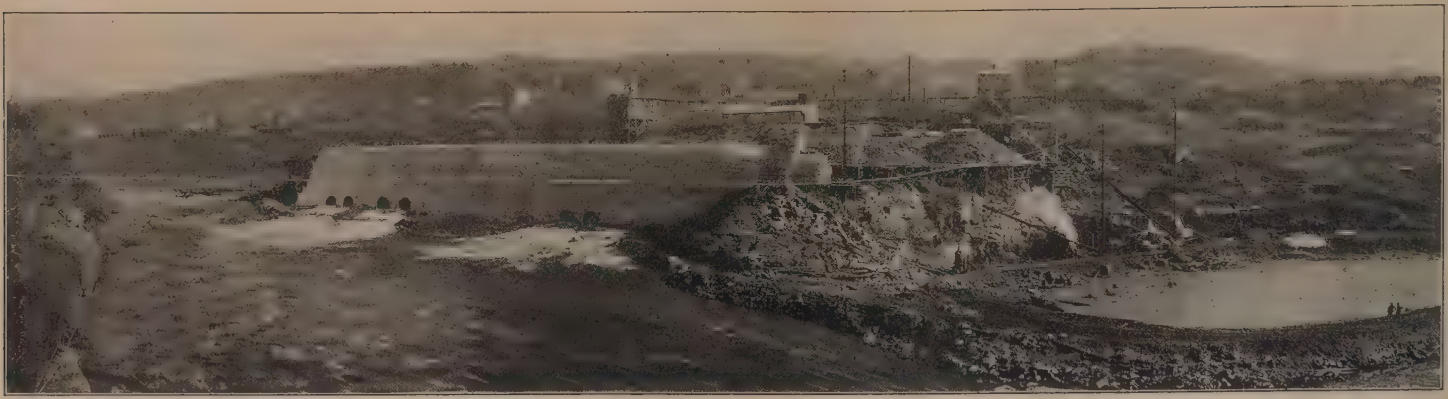
The Taylor's Falls, Minn., Water Power Development.—II.

Transmission Line.—At present one transmission line has been built on private right-of-way from the power station to the step-down sub-station at the city limits of Minneapolis and St. Paul. The right-of-way is practically straight and in general is 60 ft. wide, being laid out for a pole line 10 ft. from each boundary line. The present line, which is 40.6 miles long, is of 4/0 semi-hard-drawn copper cable carried on wooden poles, with the exception of certain long spans across swamps, lakes or other obstructions where Aermotor steel towers are used. The standard pole of the transmission line is of Idaho cedar, 45 ft. long, carrying 5 x 7-in. cross-arm, 7 ft. 4 in. long, and a small cross-arm 7 ft. below for the telephone line. The transmission wires are carried on four-part porcelain insulators of special design, which are arranged on a 72-in. equilateral triangle with the apex at the top of the pole. The top insulator is cemented to a bracket pin swedged out of extra heavy 2-in. iron pipe, while the cross-arm insulators are carried on pins of the same material set into the arm in the usual manner. The cross-arms are bolted to the poles, braced with a single angle iron on one side and fitted with bolts through and on each side of each pin to hold the pin firmly and to prevent splitting of the arm. The standard span on pole construction is 140 ft., the spans on the tower construction reaching up to 600 ft.

The telephone line consists of two No. 10 copper wires connecting permanent instruments at each power station and at a patrolmen's cottage at the centre of the line, and with temporary connections in booths arranged along the line for the use of the patrolmen. The telephone instruments and connections are all arranged with high insulation repeating coils to protect the attendants against possible shock from induction from the transmission line.

Owing to the prevalence of thunder storms over the middle portion of the transmission line, this part is protected by several different experimental constructions of overhead grounded wires, lightning rods on the poles and also on separate poles arranged alongside and reaching above the transmission line. The Westinghouse Co. standard low equivalent arresters are used to protect the station apparatus at both ends of the line and in addition three types of horn arresters and other special devices have been put up.

Main Step-Down Sub-Station.—The step-down sub-station is built of brick and steel with reinforced-concrete floors, and has a timber framework to support the wiring, which is open throughout. The building is divided into two rooms, one containing the transformers and the other the switchboard and wiring. The transformer room is screened off by a brick wall with a reinforced-concrete floor overhead. The entrances of present and future transmission lines are at one end of the building, while exits for three 13,000-volt outgoing lines are provided along each side. Three banks of transformers duplicating those at the power station are now installed with provision for three additional banks in future. These transformers are now connected for stepping down from 47,500 to 13,800 volts.



Arrangement of Construction Plant for Taylor's Falls Station.

The wiring consists of two high-tension busses and two low-tension busses to be joined in the future in each case by a junction switch at the end of the building. The transformers and incoming and outgoing lines are controlled by Westinghouse oil switches mechanically connected to lever handles on the switchboard, which is arranged on the second floor across the building near the transmission line end. The oil insulated choke coils, instrument transformers and high-tension lightning arresters are arranged on a reinforced-concrete gallery at the end of the building and the arresters and oil switches controlling the outgoing lines are arranged on the second floor and gallery above. The transformers are provided with an oil treating system similar to the one at the power station. Water for cooling the transformers is pumped from a deep well and circulated by motor-driven turbine pumps and finally discharged over a cooling screen into an artificial pond outside the building. The cooling coils of each transformer are provided with Venturi meter tubes and gages to indicate the amount of cooling water used at all times and each gage is provided with electric contacts which ring an alarm and indicate by lamps in case the flow in any transformer falls below a given amount.

Construction.—The construction of the dam and power house was handled with considerable difficulty, owing to the swiftness and volume of the stream; the frequent changes in the stage of the river; the necessity of sluicing logs during the spring and summer months; the extreme toughness of the trap rock encountered in the excavation and the heavy flow of ice during the spring freshets.

The materials and equipment required in building the two structures, excepting the sand and stone used in the concrete, were brought in over a standard-gauge spur track about 1½ miles long, that was built especially for the purpose from the Minneapolis, St. Paul & Sault Ste. Marie R. R. This track extended from the end of that railroad at the village of St. Croix Falls on the Wisconsin side for about ¾ of a mile upstream to a switch back and from there back about ¾ of a mile downstream to the power house site. It ended about 150 ft. from the upstream side of the power house and was back about 250 ft. from the straight section of the spillway of the dam, parallel to the stream and 40 to 50 ft. above the bed of the latter.

The dam and power house were both built on the solid trap rock which underlies the entire site on the Wisconsin side of the river. The foundation of the power house was excavated out of this rock in the downstream side of the ledge through which the forebay canal was dug. The straight section of the dam at the power house and the downstream end of the spillway were built on this ledge after it had been stripped down below any fissures. The balance of the spillway was built on the trap rock which formed the bed of the stream after all loose rock and sand had been removed. The bear trap dam and log sluice on the Minnesota side of the river were also built in excavation made in the solid rock bank.

Concrete and Concrete Mixing Plants.—The mixture of concrete used for the greater part of the work was one part Atlas Portland cement, three parts sand and five parts broken stone. The sand was obtained from a bank 1,500 ft. from the site of the work. It was brought to the mixing plants in cars run by gravity on a track laid from the sand bank to the two mixing and crushing plants. After they had been dumped the cars were hauled back to the pit by horses.

The trap rock excavated from the canal and power house site was crushed to a size that would pass the meshes of a 2½-in. screen and then stored in bins to be used in the concrete. Large pieces of trap rock taken from the excavation, varying in size from those that could be handled by one man to those containing about one cubic yard, were placed in the green concrete of the dam and power house foundations. These pieces of rock were placed at least 1 ft. apart and 1 ft. from the surface.

A concrete mixing plant was set up beside the standard gauge spur track nearly in line with the junction of the curved and straight sections of the spillway and 150 ft. back from the latter at the top of a sharp drop in the river bank. This plant contained a 1-yd. Smith concrete mixer set on a platform about 4 ft. above the ground. Over this mixer were measuring hoppers for sand and stone, and above these the storage bins for those materials.

The rock was brought to the plant from the excavation on a narrow-gauge track which ran up an incline to the level of the crushers. It was first passed through a McCully gyratory crusher and then elevated to a 2½-in. mesh screen over the rock bin; all pieces that would not pass through this screen were returned to a No. 3 McCully crusher, which also delivered to the elevator. All rock that would pass through the screen fell into the storage bin for crushed stone.

The storage shed for cement was erected alongside the spur track; cement was delivered from this shed to the charging platform of the mixer on push cars. The straight section of the spillway was built from tracks on a temporary trestle about 15 ft. below the top of the dam. This trestle carried three tracks; one of standard gauge on the dam side, a 36-in. gauge next, and a 24-in. gauge on the outside, with extra rails

View of Cofferdam and Upstream End of Straight Section of Spillway during a Freshet.

provided in the outer tracks and arranged so that a 24-in. and a 36-in. gauge track were also made on that side. These tracks were connected with the mixer by a trestle which ran from it to the main trestle. The standard-gauge track carried two cars, each mounted with a guyed derrick having a 60-ft. boom. These derricks handled the rock excavated from the site of the dam; the forms for the concrete and the skips in which the concrete was delivered on the cars from the mixer.

What little coffer-dam work was necessary for this portion of the dam was done with gravel brought from an adjacent gravel bank. This section of the dam contained at the base three pairs of 9x12-ft. arched openings which were left to provide for the passage of the river while the closing section of the dam was being built.

After the work had been in progress for a few months a second crushing and mixing plant, a duplicate of the first, was erected on the river bank above the site of the power house and 300 ft. downstream from the first plant. A trestle connected this second plant with the main trestle along the dam.

The second portion of the dam crossing the bed of the river was a more serious proposition to construct than the first, owing to the liability of sudden and rapid changes in the stage of the stream. The cofferdam to turn the river while this portion of the dam was being built was constructed of log crib work, weighted down with rocks taken from the excavation. Sheet piling was placed on the upstream side of the crib work and gravel and clay were used to fill the interstices of the rock in the cribs. Large quantities of brush were also placed outside of the sheet piling and clay and gravel dumped over them, this method of construction being found very effective in the swift curent of the congested channel.

The concrete for this portion of the dam was brought to position in dump cars running on a track blocked up on top of the completed portion. An elevator brought the dump cars of concrete to position on this track from the lower level of the trestles running from the two mixing plants. From the dump cars the concrete was placed through chutes extended to the work from the end of the track. As the dam was completed the latter was gradually extended. This method of placing the concrete was found to be faster than the use of derricks, and gave excellent results.

The foundations of the power house were largely put in in the winter with the temperature at times as low as 20° below zero, Fahr. For this winter work one of the mixing plants was fitted up so that live steam could be run through the sand and rock bins and into the water tank. In very cold weather salt was also used in the water. The concrete thus made was found to be hot enough to get its initial set before it could freeze and the results obtained were uniform and excellent.

The concrete for the bear trap dam and sluiceway for logs was procured from a separate plant set up on the Minnesota side of the river. This plant consisted of a ½-yd. Smith mixer placed on the river bank immediately above the site of the work. Most of the concrete supplied by this mixer was put in position through a chute running directly from the latter to the point where concrete was being laid. In such portions of the work as could not be reached in this way the concrete was handled by a derrick set in the lower end of the sluiceway.

The dike on the Minnesota side of the river was built of gravel concrete on a stratum of hardpan and sandstone. A separate concrete mixing plant was installed for this work, using the same ½-yd. Smith mixer which was employed in the construction of the bear trap dam. A trestle ran from this mixer immediately above the dike and on this trestle the concrete was handled in dump cars from which it could be put directly in position. The sand and gravel were obtained from a bank near by which was connected with the plant by narrow-gauge tracks.

The plans for the Taylor's Falls development were prepared by Messrs. Stone & Webster, of Boston, Mass., and the construction work and installation of the machinery in the power house were executed under their direction. Messrs. Dean & Main, of Boston, were the consulting engineers in connection with the preparation of the plans for the hydraulic features of the development. Messrs. Loweth & Wolfe, of St. Paul, Minn., conducted the preliminary hydraulic investigation.

Gasoline Motor Service on the Union Pacific Ry.

An interesting innovation in railway passenger transportation in this country will be inaugurated next month, when, it is announced, the Union Pacific Ry. will place in service twelve gasoline rail-motor cars. The cars are intended for branch-line traffic, where the fast and frequent service required cannot be maintained by ordinary trains except at a loss.

The lastest type of these cars developed at the Omaha shops of the Union Pacific makes 60 miles an hour with a 200 h.-p. engine, reaches high speed within six car lengths, and can be stopped within 120 ft. With these advantages the cars can be put on a much faster schedule than is possible with the steam locomotive.

Outwardly the newest of the cars, which are built entirely of steel, resemble a turned-over racing yacht. The forward end tapers sharply, and the roof and rear are rounded off to reduce the air resistance and avoid the vacuum produced by a square car. Rounded windows give to the passengers a wide range of outlook, and increase the nautical appearance of the car.

In cold weather the cars are to be heated by hot water from the cylinder jacket. They are lighted by acetylene gas shining through opalescent panels.

For sanitary reasons the floors of the cars are built so that they can be thoroughly cleaned by flushing with hot water. The familiar system of ventilation has been replaced by roof ventilators which exhaust the inside air by suction, fresh air being taken in from the car roof in front. Vibration is reduced to a minimum by the way in which the motor is balanced.

The cost of operating the cars varies from ten to twenty cents a mile, according to the density of the traffic, but the records kept indicate that the rail-motor car will make possible great improvements in handling branch-line passenger traffic.

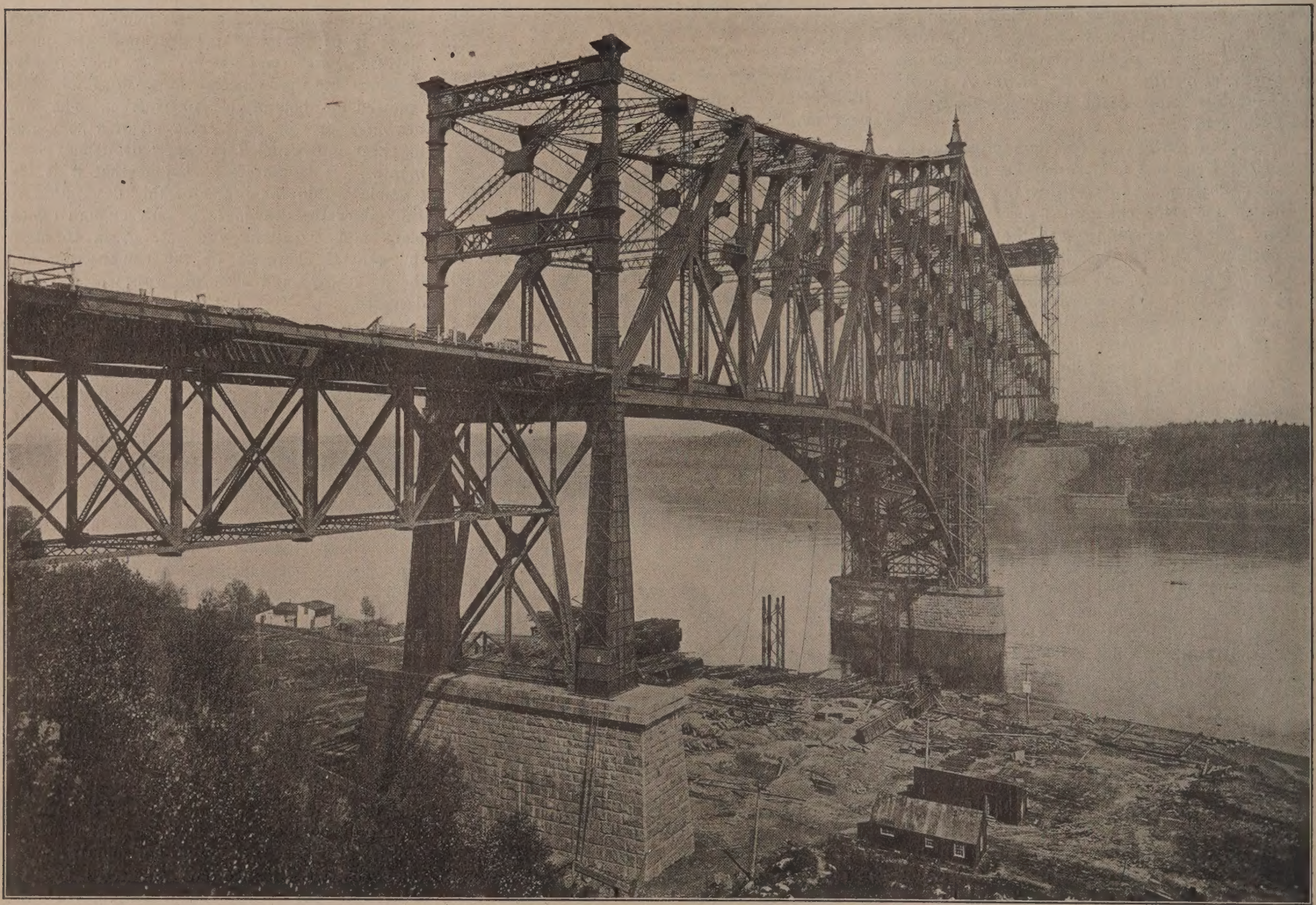
THE FREEZING PROCESS of sinking shafts has been successfully employed at a colliery at Seaham, England. At this place there is a deep bed of limestone under which is a 92-ft. stratum of water-bearing sand. The limestone also carries much water. Twenty-eight bore holes were marked off in a circle 30 ft. in diameter around the shafts and were sunk to a depth of 484 ft. Pipes were placed in these holes and connected with apparatus producing a circulation of brine, which formed an ice wall in 185 days. The sand was struck at a depth of 371 ft. after the freezing had been completed, and was found to be so hard as a result of the process that blasting was necessary in places. When the shaft had been sunk through the water-bearing materials, the ground was thawed by circulating warm brine through the freezing tubes.

The Quebec Bridge Superstructure Details.—II.

Vertical Bents on Main Piers—Pedestal.—The 166,000-lb. pedestal is seated on the bolster and is pin-connected to the foot of the main post. It is a 11x13-ft. frustum of a rectangular pyramid and is about 8 ft. high. The construction, although of a simple type corresponding with that of the ordinary pedestal for a bridge truss bearing, was rendered very difficult on account of the great thicknesses required for the different bearings, the necessity of securing perfect contact between the webs and base, the provision of satisfactory connections for such large stresses in oblique directions and the arrangement of details to avoid costly operation and make the shop work conform to regular standing. The construction, involving a great number of pieces, made it necessary to provide numerous plans, elevations and sections, to show their relative positions and the numerous dimensions and notes required for their proper construction. The shop drawings, at 1-in. scale cover all of a 39 x 130-in. sheet and occupied an expert draftsman seven months. It is therefore obvious that it is impossible within the limits of this description to fully show the drawings; so only enough typical plans and elevations are here given to show the general character of the construction and the great care and accuracy with which it was designed.

The base plate 3 in. thick is planed on both sides and is made with three pieces with a planed butt joint on the longitudinal center line of the pedestal. To it are riveted five vertical longitudinal webs bored for the 24-in. pin 7 ft. long, which receives in them a total bearing nearly 3½ ft. long, thus reducing the pressure on the metal to the allowed unit stress of 28,000 lbs. per sq. in. All of the webs are built up of 1-in. intermediate plates and 1⅛-in. outside plates, riveted together to make up the required thicknesses. The outside webs are made with 6 plates each and the intermediate webs with 10 plates each. In the outside webs all plates receive full holes, but in the intermediate webs the two outer plates on each side of each web terminate on the center line of the pin so that they only have half-hole bearings while the inner plates have full holes. The webs are connected to the base plates with special angle sections made by cutting off one flange of a 15-in. channel, thus leaving a vertical leg 15 in. long, through which 5 rows of rivets are placed while only a single row is driven through the comparatively narrow lower horizontal flange. The webs are stiffened and connected by five lines of transverse vertical diaphragms of different types according to the clearances required for the pins and connecting members. Each diaphragm is made with four 6 x 8-in. angles, two of them riveted back to back on the face of one diaphragm to form a T-bar section and the other two riveted to the opposite diaphragms with their outstanding flanges separated far enough to clear and engage the outstanding flanges of the first pair. The interlocking flanges are connected by bolts close together since the space does not permit driving rivets through them. The outer webs are located about 3½ ft. clear of the edges of the base plate and are provided on their outer faces with five heavy vertical transverse diaphragms in the plane of the interior diaphragms, which help distribute their load and stiffen the base plates to transmit the pressure uniformly over its entire surface. The inclined edges of all the diaphragms are stiffened with pairs of 6 x 8-in. flange angles. Most of the webs are single 1-in. plates, but in the two diaphragms nearest the center one the webs are made of three thick plates and the two outer plates are bent at the inner edge to form flanges riveted to the main web instead of connecting angles. Angles with one long and one very narrow flange are made by cutting off one flange of a 10-in. channel and partly cutting off the other and are riveted to the inclined outer edges of the main web to receive cover plates put on to give them a neat finish and exclude water from the open joints.

The pedestal is provided with horizontal and inclined transverse connection plates forming pairs of jaws field riveted to the ends of the lower chord sections and bottom lateral members. As very heavy stresses are transmitted through these connections great care was taken in designing them; they were accurately fitted in the shop to large details accompanying the general drawing as shown in the sketch herewith reproduced. The pedestal is connected to the bolster by seventy-six 1⅛-in. vertical bolts. The spaces between the webs are closed as much as possible to exclude rain, snow and rubbish; drainage holes are provided in the upper transverse plates and in the lower edges of the outside cover plate to permit the melted snow and rain to escape as much as possible. The dimensions of the pedestal are so great that it was found impossible to ship it from the shop to the bridge site on an ordinary car or in an ordinary manner. It was therefore transported as noted in The Engineering Record of September 16, 1905, on a special steel car, built for the purpose with an unfloored frame-work of heavy girders, from which the pedestal was suspended by a heavy box girder passing through its pin hole and allowing it to be suspended with its lower edge 6 inches clear of the top of the rails.



View of Approach Span, and of South Anchor and Cantilever Arms.

The vertical post is the most important single member connected to the pedestal and it has a special shoe riveted to the lower end with four vertical longitudinal webs engaging the 24-in. pin which locks it to the pedestal. The shoe is 9 ft. high and weighs 67,000 lbs. The 5½ x 10-ft. horizontal upper surface, corresponding to the base plate of the pedestal, is made with a single 1¼-in. plate, planed on both sides and secured by about 200 field rivets to the corresponding horizontal plates in the bottom of the lower section of the vertical posts. The four webs clear those of the pedestal and are each 6¾ in. thick, thus providing a combined bearing 27 in. long for the transmission of the 10,000,000 lb. stress in the post to the pedestal. Each web is built up of four ¾-in. plates, three plates being cut off on the center line of the pin so as to afford half-hole bearings and the fourth plate being extended to receive a full hole and thus lock the shoe to the pin. The webs are connected by four lines of inclined diaphragms, those between the outer pairs being made like those described for the pedestals with two pairs of engaging angles back to back riveted to their adjacent faces. The space between the inner webs is sufficient to enable their diaphragms to be made in the usual manner with a ¾-in. web plate and two pairs of 8x8x¾-in. flange angles. Between the flange angles the web plates are reinforced by pairs of ¾-in. cover plates, giving them a uniform thickness throughout of 2¼ in.

The shoe is provided, like the pedestal, with horizontal and inclined transverse plates perpendicular to its web which engage the upper flanges of the lower chord sections and are thoroughly field riveted to them. The connection plates are shop riveted to the outside webs and are reinforced in the center by heavy brackets with their lower ends faced to bearing against the plates.

The main lower chord pin which connects the pedestal and shoe is 24 in. in diameter, about 7 ft. long and weighs 10,000 lbs. It is doubtless the largest pin yet constructed for a bridge truss; it is made from open hearth steel of about 70,000 lbs. tensile strength, forged under a pressure of 5,000 tons; it has a hole 6 in. in diameter through its axis, through which a 1½-in. rod passes to connect and hold in position the steel discs covering the ends of the pins in lieu of nuts.

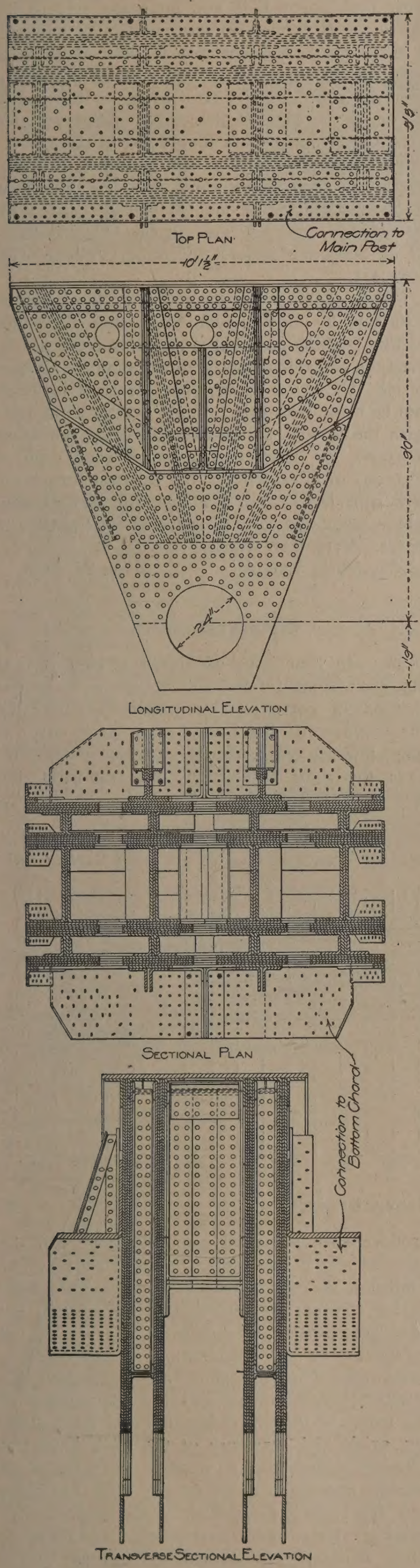
Between the outer webs of the shoe and pedestal it receives the webs of the short end sections of the lower chords which are reinforced to total thicknesses of 6¾ in. These are made with full-hole bearings in V-shaped special sections about 14 ft. long and weigh about 120,000 lbs. each; they were assembled with the shoe and the pedestal, independent of the main sections of the lower chords, which were spliced to them at convenience later. Notwithstanding the mass and rigidity of the members they were designed to fit together with clearances of only 11/16ths in. on the main pin; they were so truly dimensioned and the shop work was so accurately executed, that they were assembled without difficulty in the field. The diagonal members of the truss are theoretically connected to the short pin on which their center lines intersect, but for convenience they are made with separate connections, field riveted to the foot of the lower section of the vertical post.

The accompanying view of the bridge was made from a photograph taken June 12, and is the first picture published which shows the structure from this point, looking upstream, and including the approach span and the complete substructure on both sides of the river. It shows the completed 600-ft. anchor arm and the 562½-ft. cantilever arm and gives an especially clear view of the south anchor pier and the riveted towers on it enclosing the vertical eyebars extending from the end pins to the anchorage platform enclosed in the base of the pier.

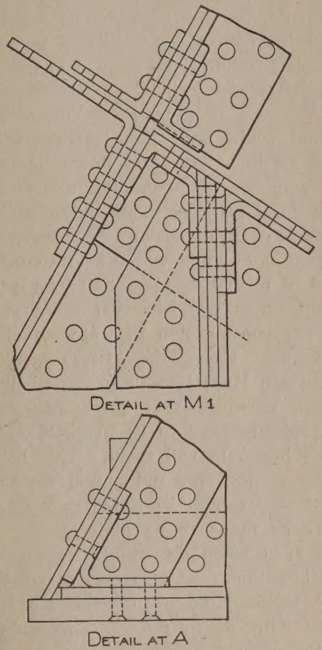
The falsework has all been removed except the bents on the main pier, outside the trusses, and the lower story of the last two bents on shore, and part of it can be faintly seen erected on the opposite shore, half a mile away, while a portion remains piled on the near shore ready for transportation to the other side. The temporary erection girders are still suspended from the extremity of the cantilever and the great traveler supported on them is being dismantled for reerection on the opposite side of the river. All the principal members are in position in the anchor and cantilever arms and they are completed except for part of the field riveting, which is still in progress from scaffolds, almost imperceptible to the scale of the picture, which are suspended from different points of the lower chords and elsewhere.

All of the 3,202 eyebars have been completed, 23,000 tons of steel have been shipped to the site, 12,000 tons more are completed and held in storage at the bridge shops, and only about 3,000 tons more are yet to be riveted in the shops. The steel for the north half of the bridge is being stored in a yard established about 8 miles from the river, at the nearest point now accessible by railroad, where there has been installed an electric traveling crane and service tracks corresponding with those for the south side, described in The Engineering Record of March 4, 1905.

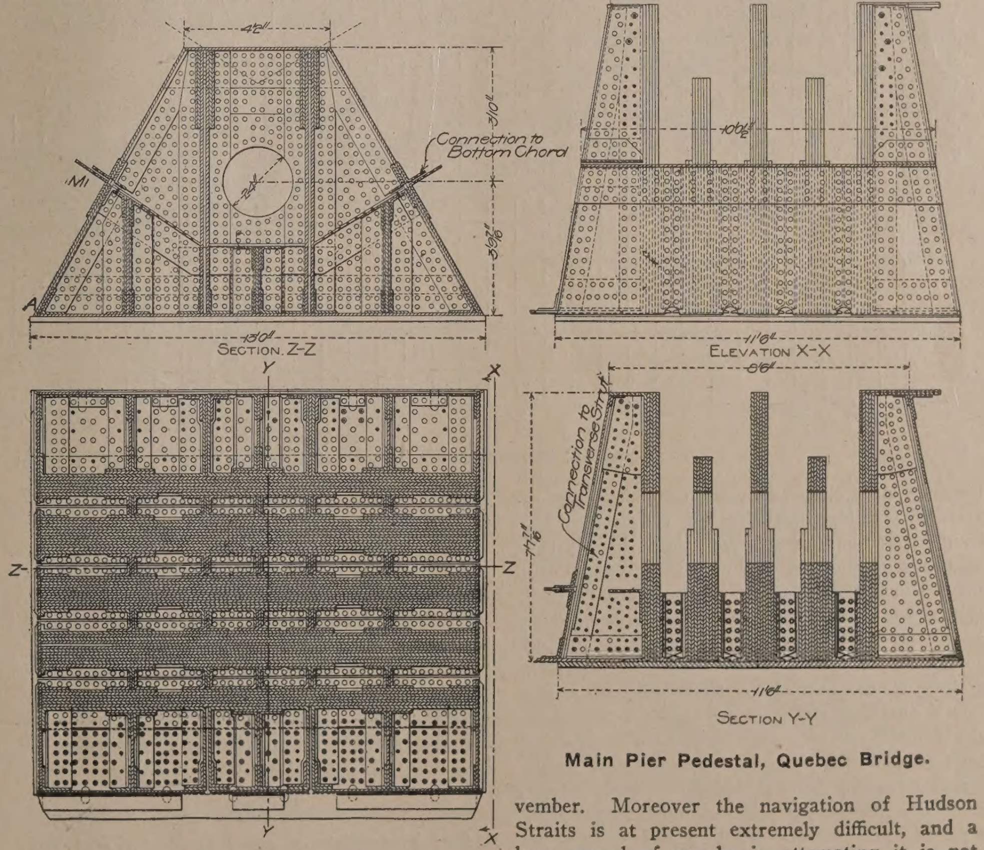
The railroad track is under construction from these yards to the bridge site, and as soon as it is completed the materials will be forwarded to the river and the north anchor arm, north cantilever and north half of the suspended span will be erected in the same manner as previously adopted for the corresponding south portions of the bridge. It is expected that this construction can be commenced early in 1908 and meantime a smaller overhead traveler will be built to run on the top chord and will, this summer, erect as a cantilever the south half of the 675-ft. suspended center span.



Shoe for Main Post.



Web and Base Plate Connections of Pedestal.



Main Pier Pedestal, Quebec Bridge.

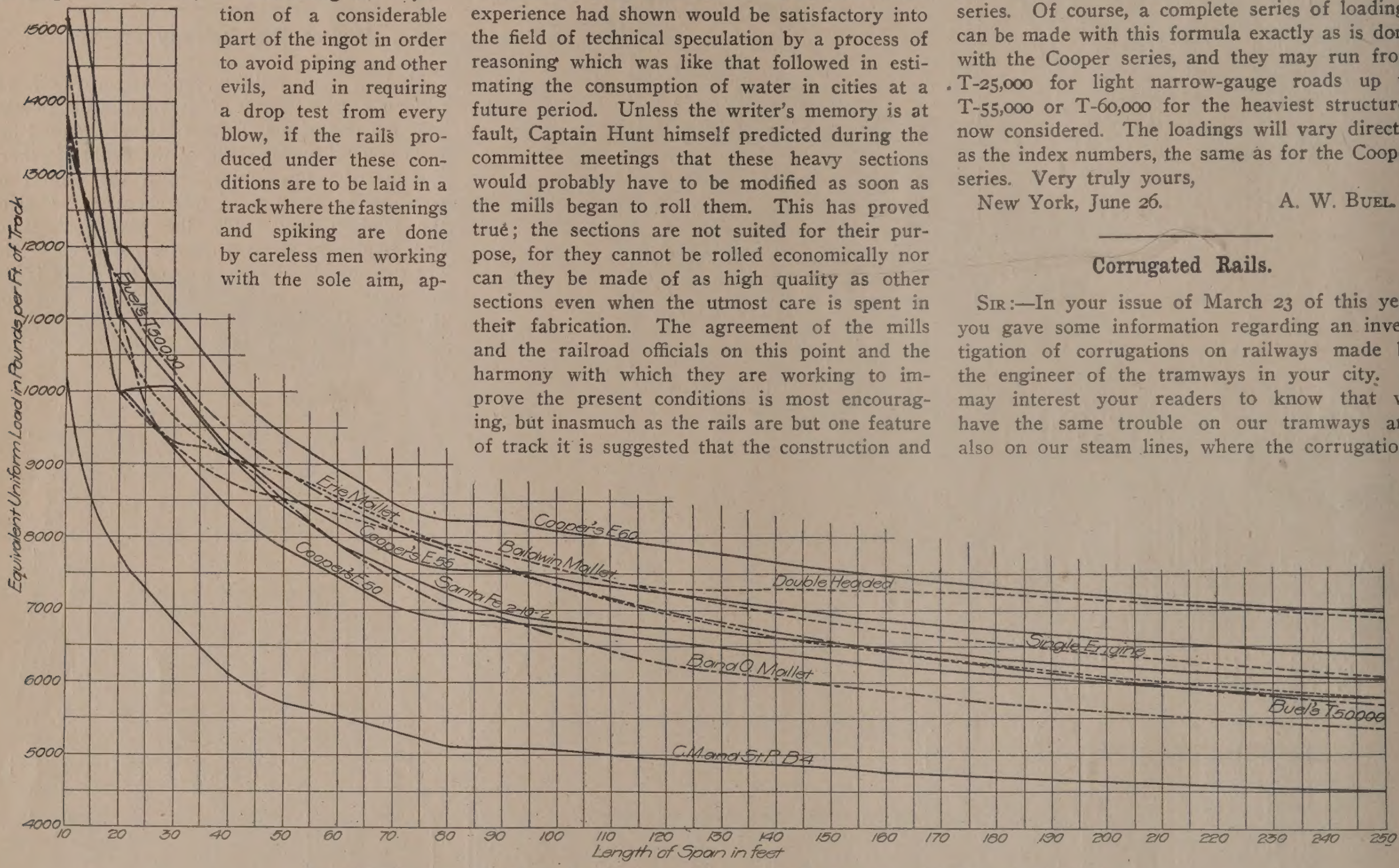
Hudson Bay Railway Projects.

Hudson Bay railway projects are now receiving a large amount of attention in the Dominion, and one of the charters for such a road has been secured by Mr. Hill, of the Great Northern system, who formerly ridiculed the project of constructing any line of this character. One of the Hudson Bay roads, the MacKenzie-Mann line, is already about a quarter completed. The great geographical advantage of the route is the shortness of the railroad haul to the ports on the Bay. Unfortunately the season of navigation in Hudson Bay is limited to the short period between the middle of June and the middle of November. Moreover the navigation of Hudson Straits is at present extremely difficult, and a long record of wrecks in attempting it is not particularly encouraging. Nevertheless it seems safe to say that the attention now being paid to the Hudson Bay route is bound to result in a great deal of more definite information concerning its practicability, and possibly before long such a line will be constructed. The Canadian Premier has advocated liberal subsidies to companies undertaking the work.

Letters to the Editor.

RAILS AND TRACK.

Sir: Those who have followed the recent discussion concerning the quality of steel rails and at the same time have been in a position to know the manner in which rails are laid in some tracks probably will agree with the writer that the railway officials who are showing so much interest in improving the quality of the rails used on their line would do well to look at the same time into the way in which track construction and maintenance is carried on. Every one must agree that the precautions which seem likely to be taken to secure better rails, even at a considerably higher first cost, are so eminently in the line of an increase in safety as to deserve the heartiest support of stockholders and the traveling public. On the other hand, there seems to be some inconsistency in devising new sections, in demanding the rejection of a considerable part of the ingot in order to avoid piping and other evils, and in requiring a drop test from every blow, if the rails produced under these conditions are to be laid in a track where the fastenings and spiking are done by careless men working with the sole aim, apparently, of getting the work completed just as fast as possible regardless of character. The brutality of the spiking is sometimes directly preventative of good track conditions. The punishment which rails received when laid improperly can be witnessed by any observant person during a ride of any length. It is generally possible to notice the action of the track under passing freight trains, even in a short ride of a few hours' duration, and after witnessing a few times the pounding of the rails and their vertical vibrations under heavy freight cars and under Pullmans, if one is fortune enough to have an opportunity to witness that, a most illuminating idea of certain track troubles and their cause can be formed. Unquestionably Mr. P. H. Dudley is entirely correct in his statement reported in your issue of last week that the average track on the New York Central lines is much stiffer than it was twenty years ago, owing to the use of heavier rail sections, but there are many lines in this country carrying very heavy trains which are not laid with rails of the New York Central weight and do not keep their roadbed up to such a high standard of maintenance.



Graphical Comparison of Typical Engines with a Few Recent Heavy Engines.

These remarks are made without any intention of criticising the present apparent determination of the railway companies to purchase better rails even at an increased cost. There is every reason for improving the quality of rails, as was very well shown at the discussion of the American Society for Testing Materials at its recent convention. Very likely one reason that improvement in the quality of rails has not been more marked during recent years has been the adherence to the Am. Soc. C. E. standard sections for the heavier rails. Those sections were devised, as Captain Hunt pointed out at the convention mentioned, by a committee which had to work absolutely in the dark. Very likely Captain Hunt could have gone farther and stated that the sections were laid down by that mitttee with the understanding that they would probably need material modification, and were a compromise or an extension of the sections which experience had shown would be satisfactory into the field of technical speculation by a process of reasoning which was like that followed in estimating the consumption of water in cities at a future period. Unless the writer's memory is at fault, Captain Hunt himself predicted during the committee meetings that these heavy sections would probably have to be modified as soon as the mills began to roll them. This has proved true; the sections are not suited for their purpose, for they cannot be rolled economically nor can they be made of as high quality as other sections even when the utmost care is spent in their fabrication. The agreement of the mills and the railroad officials on this point and the harmony with which they are working to improve the present conditions is most encouraging, but inasmuch as the rails are but one feature of track it is suggested that the construction and maintenance of the track itself might very properly be taken up with the same thoroughness at this time, so that by the time the mills are rolling better rails they will be used in a better manner. At the convention of the American Society for Testing Materials, one railroad officer stated that if the mills could not furnish a better quality of rails, unquestionably they would be subject to some kind of legislation; it is only reasonable to expect that probably the same kind of legislation might be directed at the railroads if they do not improve their track methods. X.

Bridge Loadings.

Sir: The article on pages 712 and 713 of The Engineering Record of June 15, "A Comparison of E-50 Loading with Recent Heavy Locomotives," is very interesting and valuable. I have platted on the diagram on page 712, showing the graphical comparison of equivalent uniform loads from typical engines and a few recent heavy engines, another line (see accompanying diagram) showing the equivalent uniform load by my formula, using the index 50,000. This loading I have called T-50,000. The curve of the T-50,000 lies just slightly above all actual loads and above Cooper's E-55 for all spans between 18 ft. and 50 ft. For spans under 16 ft. it is very close to Cooper's E-50 and for spans over 50 ft., up to 250 ft., it crosses the Erie Mallet twice at a span length of about 100 ft., and again at a span length of about 170 ft., but for all spans between 50 ft. and 250 ft. it seems to follow the curve of the Erie Mallet single engine without departing from it more than 2 per cent.

This system of loading was presented at a discussion of the committee report of the American Railway Engineering and Maintenance of Way Association and published in the "Proceedings" of its Seventh Annual Convention, Volume VII, page 211.

I thnk that a mere inspection of the diagram with this line on it is sufficient to show the value of this loading, and that it seems to more nearly meet the actual loadings of to-day than the Cooper series. Of course, a complete series of loadings can be made with this formula exactly as is done with the Cooper series, and they may run from T-25,000 for light narrow-gauge roads up to T-55,000 or T-60,000 for the heaviest structures now considered. The loadings will vary directly as the index numbers, the same as for the Cooper series. Very truly yours,

New York, June 26. A. W. Buel.

Corrugated Rails.

Sir:—In your issue of March 23 of this year you gave some information regarding an investigation of corrugations on railways made by the engineer of the tramways in your city. It may interest your readers to know that we have the same trouble on our tramways and also on our steam lines, where the corrugations produce such a special sound that we call the rails on which they occur "roaring rails." The engineers of our North-Eastern Ry. have been paying considerable attention to the subject, but have been unable to discover the cause of the corrugations. An examination of many corrugated rails failed to show any connection between the corrugations and the composition of the metal or its fabrication, nor did the ballasting, grade and curvature of the track have any apparent influence. A number of rails, some roaring and some quiet, of the same character and from similar locations were subjected to physical tests and microscopic examination. Their hardness was ascertained by the Unwin knife-edge test, which showed that the roaring rails were harder than others, while tension tests showed that the metal at the high points of the roaring rails was stronger as well as harder than that in the low parts. The microscopic and chemical examinations gave no clue to the cause of the corrugations.

Trams.

London, June 11.